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SUBSTITUTE CHEMICAL PROGRAM
INITIAL SCIENTIFIC AND MINIECONOMIC REVIEW OF METHYL PARATHION

MIDWEST RESEARCH INSTITUTE

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

FEBRUARY 1975

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emulsifiable concentrates
U.S. Tolerances
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toxicity - mammals
amounts absorbed by workers
ULV-treated fields
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U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDE PROGRAMS
CRITERIA AND EVALUATION DIVISION
WASHINGTON, D.C. 20460

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This report has been compiled by the Criteria and Evaluation Division, Office of Pesticide Programs, EPA, in conjunction with other sources listed in the Preface. Contents do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

PREFACE

The Alternative (Substitute) Chemicals Program was initiated under Public Law 93-135 of October 24, 1973, to "provide research and testing of substitute chemicals." The legislative intent is to prevent using substitutes, which in essence are more deleterious to man and his environment, than a problem pesticide (one that has been suspended, cancelled, deregistered or in an "internal review" for suspected "unreasonable adverse effects to man or his environment"). The major objective of the program is to determine the suitability of substitute chemicals which now or in the future may act as replacements for those uses (major and minor) of pesticides that have been cancelled, suspended, or are in litigation or under internal review for potential unreasonable adverse effects on man and his environment.

The substitute chemical is reviewed for suitability considering all applicable scientific factors such as: chemistry, toxicology, pharmacology and environmental fate and movement; and socio-economic factors such as: use patterns and costs and benefits. EPA recognizes the fact that even though a compound is registered it still may not be a practical substitute for a particular use or uses of a problem pesticide. The utilitarian value of the "substitute" must be evaluated by reviewing its biological and economic data. The reviews of substitute chemicals are carried out in two phases. Phase I conducts these reviews based on data bases readily accessible at the present time. An Initial Scientific Review and Minieconomic Review are conducted simultaneously to determine if there is enough data to make a judgment with respect to the "safety and efficacy" of the substitute chemical. Phase II is only performed if the Phase I reviews identify certain questions of safety or lack of benefits. The Phase II reviews conduct in-depth studies of these questions of safety and cost/benefits and consider both present and projected future uses of the substitute chemicals.

The report summarizes rather than interprets scientific data reviewed during the course of the studies. Data is not correlated from different sources. Opinions are not given on contradictory findings.

This report contains the Phase I Initial Scientific and Minieconomic Review of Methyl Parathion (0,0)-dimethyl 0-p-nitrophenyl phosphorothioate). Methyl parathion was identified as a registered substitute chemical for certain cancelled and suspended uses of DDT. Where applicable, the review also identifies areas where technical data may be lacking so that appropriate studies may be initiated to develop desirable information.

The review covers all uses of methyl parathion and is intended to be adaptable to future needs. Should methyl parathion be identified as a substitute for a problem pesticide other than DDT, the review can be updated and made readily available for use. The data contained in this report was not intended to be complete in all areas. The review was coordinated by a team of EPA scientists in the Criteria and Evaluation Division of the Office of Pesticide Programs. The responsibility of the team leader was to provide guidance and direction and technically review information retrieved during the course of the study. The following EPA scientists were members of the review team: William Burnam, (Pharmacology and Toxicology), team leader; Merry L. Alexander (Chemistry), Howard Kerby, Ph.D. (Fate and Significance in the Environment); Thomas Freitag (Fate and Significance in the Environment); Ellis Thomas, Ph.D. (Registered Uses); Jeff Conopask (Economics); Richard Simpson (Economics).

Data research, abstracting and collection was primarily performed by Midwest Research Institute, Kansas City, Missouri (EPA Contract #68-01-2448). RvR Consultants, Shawnee Mission, Kansas, under a subcontract to Midwest Research, assisted in data collection. Manufacturers of methyl parathion (Kerr McGee, Stauffer, Monsanto and Helena) made recommendations and additions to this report. The recommendations of the following National Environmental Research Centers, EPA Office of Research and Development have also been incorporated: Pesticide and Toxic Substances Effects Laboratory, Research Triangle Park, North Carolina; Gulf Breeze Environmental Research Laboratory, Gulf Breeze, Florida.

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PART I. SUMMARY

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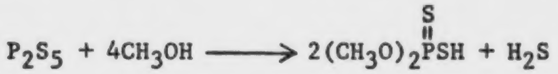
This section contains a summary of the "Initial Scientific and Minieconomic Review" conducted on methyl parathion. The section summarizes rather than interprets scientific data.

Production and Use

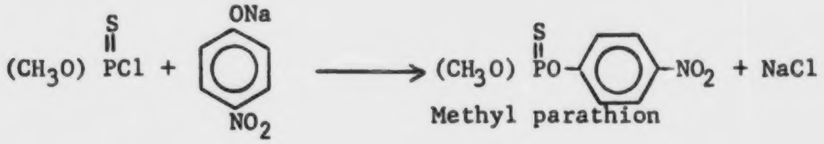
Methyl parathion (0,0-dimethyl 0-p-nitrophenyl phosphorothioate) has a broad spectrum of effectiveness against insects and is effective against some species of mites. It is registered and recommended for use in the United States on a large number of crops, including important field, forage and vegetable crops.

Three reactions are involved in the synthesis of methyl parathion:



$$P_2S_5 + 4CH_3OH \longrightarrow 2(CH_3O)_2\overset{\overset{S}{\|}}{P}SH + H_2S \qquad (1)$$

$$(CH_3O)_2\overset{\overset{S}{\|}}{P}SH + Cl_2 \longrightarrow (CH_3O)_2\overset{\overset{S}{\|}}{P}Cl + HCl + S \qquad (2)$$



(3)

An estimated 51 million pounds of this active ingredient were produced in the United States in 1972 by four manufacturers. Methyl parathion imports in 1972 were reported to be 1.1 million pounds; exports for that year are estimated to have been 12.5 million pounds. Thus, domestic usage of this active ingredient in 1972 is estimated to have been about 40 million pounds.

Methyl parathion is commercially available in a number of liquid, powder, and dust formulations. No granular or aerosol formulations, however, are registered.

In recent years, practically all domestic methyl parathion usage has been in agriculture; no significant use has been made by either the industrial, commercial, governmental, or home and garden sectors. We estimate that, in 1972, about 33.5 million pounds (85% of the total domestic usage) were used on cotton; 3.1 million pounds were used on soybeans; the balance was used on other field crops, vegetables, and on other crops, and for control of mosquito larvae.

It is estimated that about three-fourths of the total 1972 domestic usage of methyl parathion was used in the South Central states. The remaining one-fourth of the total methyl parathion volume was used, in decreasing order of usage, in the Southeast, the Southwest, the Northwest, and in the North Central states. There were no significant uses of methyl parathion in the Northeast in 1972.

Toxicity and Physiological Effects

Methyl parathion is a highly poisonous insecticide. Acute oral toxicities (LD_{50} values) for methyl parathion in various mammalian species cover a wide range: 11.1 mg/kg in male rats, 18.5 mg/kg in mice, 417 mg/kg in guinea pigs, and 1,270 mg/kg in rabbits. The acute toxicity of methyl parathion to rats was found to be as follows:

Route of entry	Measurement		Value
Oral	LD_{50}		11.1-16.0 mg/kg
Intraperitoneal	LD_{50}		3.6 mg/kg
Dermal	LD_{50}		67 mg/kg
Inhalation	LC_{50}	1 hr	0.2 mg/ℓ
	LC_{50}	4 hr	0.12 mg/ℓ

Published data on the effects of methyl parathion in humans are limited. No data were found to indicate the lethal dose of methyl parathion for man. Humans have been shown to tolerate oral doses of 20 mg/'ay of methyl parathion (approximately 0.28 mg/kg/day) for 4 weeks without any significant changes in plasma or RBC cholinesterase levels.

Methyl parathion and methyl paraoxon are readily absorbed through the skin and from the stomach. Injected methyl parathion can be detected in several organs and tissues, but is most concentrated in the liver and lung. Demethylation is the principal detoxifying pathway for methyl parathion. Excretion products of methyl parathion are dimethyl phosphoric acid, methyl phosphate, methyl phosphorothioate, dimethyl phosphorothioic acid, and phosphoric acid.

A dosage of 30 ppm (approximately 1.5 mg/kg/day) of methyl parathion in the feed of rats has been shown to reduce reproductive performance; 10 ppm (approximately 0.5 mg/kg/day) did not reduce reproductive performance. It has also been shown for quail that a daily intake of 60 ppm of methyl parathion reduces the hatchability of their eggs.

The teratogenic effects of methyl parathion have been studied in rats; no gross abnormalities were produced in the embryo or the young when the mothers were injected with methyl parathion at dosages of 4 and 6 mg/kg of body weight. Another investigation did not indicate any malformation of young rats when the dosage was raised to 15 mg/kg of body weight. Lethality, suppression of growth, and some teratogenic effects were produced in the young of mice when the injected dosage was raised to 60 mg/kg.

No information was found on the possible oncogenic effects of methyl parathion. No chromosomal aberrations were found in bone marrow cells of mice that had been injected with 5, 10, and 20 mg/kg of body weight of methyl parathion.

Occupational protection standards have recently become effective which prohibit unprotected workers from entering treated fields until at least 48 hr after application of methyl parathion.

Food Tolerances and Acceptable Intake

In the United States, tolerances for methyl parathion and parathion are the same. The established tolerances apply to the combined total of methyl parathion and parathion. Tolerances have been established for about 100 raw agricultural commodities.

The acceptable daily intake (ADI) for methyl parathion has been set at 0.001 mg/kg.

Environmental Effects

Methyl parathion is toxic to fish and wildlife; product labels carry a warning that birds and other wildlife in treated areas may be killed. Available data indicate that methyl parathion is considerably less toxic to fish than parathion (the 48-hr TL_m for bluegill is 8,000 µg/liter for methyl parathion, 47 µg/liter for parathion), and that a safety margin exists between the rate of methyl parathion application necessary for mosquito control, and concentrations that would harm fish.

Only a few studies of laboratory evaluations of the toxicity of methyl parathion to wildlife have been reported, and these addressed only the susceptibility of birds. Comparative dietary toxicity studies of methyl parathion showed that Japanese quail (LC_{50} = 46 ppm) were more susceptible than bobwhite quail (LC_{50} = 90 ppm), that both quail species were more sensitive than the pheasant (LC_{50} = 116 ppm), and that the mallard duck (LC_{50} = 682 ppm) was the least sensitive of the four species tested.

Methyl parathion is reported to be highly toxic to bees (e.g., the LD_{50} by topical application to adult worker bees is 0.5 μg/g). The order of toxicity of methyl parathion to this species is in the same range as that of parathion.

Very little data have been published on the effects of methyl parathion on parasites and predators. Field experiences of many cotton entomologists, however, indicate that methyl parathion, at commercial use rates, is highly detrimental to wasps, as well as to other important parasites and predators.

Methyl parathion has been shown to cause a significant increase in the content of bacteria and actinomycetes in soil at dosages 200 times higher than the concentrations produced by normal field application.

The pattern of toxicity of methyl parathion to aquatic organisms appears to be similar to that of parathion. Methyl parathion is extremely toxic to aquatic insects, toxic to the lower aquatic fauna, and relatively nontoxic to the lower aquatic flora.

Data on the degradation of methyl parathion in soils show that its half-life is generally one-fourth to one-half that of parathion. The half-life of methyl parathion, applied at 1 to 50 lb/acre to four soil types, ranged from 3 to 11 days.

Available data indicate that the soil degradation of methyl parathion is temperature-dependent.

No data were found on the fate of the initial degradation products of methyl parathion, especially p-nitrophenol and amino-methyl parathion, or on the effects of these degradation products on organisms other than mammals and insects.

Available data indicate that methyl parathion is considerably less persistent in water than parathion. Methyl parathion is hydrolyzed considerably faster than parathion. In aqueous solution, at pH 1 to 5, and 20°C, 50% of methyl parathion is hydrolyzed in 175 days (compared to 690 days for parathion). At 15°C in 1 N NaOH, 50% hydrolysis of methyl parathion is completed in 32 min. Available data, however, are insufficient for an evaluation of the extent of water contamination with methyl parathion.

Insufficient data are available on the origin, presence and persistence of methyl parathion residues in air. Thus, the magnitude or consequence of this problem cannot be evaluated.

There is no evidence that methyl parathion is biomagnified in food chains or food webs, even though some organisms, especially lower aquatic organisms, concentrate methyl parathion to some degree.

Specific Hazards of Use

The only major potential hazards associated with the registered uses of methyl parathion that have been documented by this review are its acute toxic hazard to man and, to a much lesser degree, its acute toxic hazard to many of the other higher organisms and to beneficial insects.

Limitations in Available Scientific Data

The review of scientific literature was based on available sources given limitations of time and resources. Data was not found in a number of pertinent areas:

1. Comprehensive long-term studies of the toxicity of methyl parathion in at least one species. (One multiple (3) generation reproduction study of rats has been reported, but the highest dosage tested was 30 ppm in the feed. This should include carcinogenic data.)

2. The mutagenic effects of methyl parathion.

3. The physiological effects of the major degradation products of methyl parathion.

4. The toxicity of methyl parathion to wildlife under field conditions.

5. The interactions between methyl parathion and lower terrestrial organisms.

6. The fate in the environment of the major degradation products of methyl parathion, especially p-nitrophenol and amino-methyl parathion.

7. The fate and persistence of methyl parathion residues in water.

8. The origin, presence, persistence, and significance of methyl parathion residues in air.

Efficacy and Cost Effectiveness

The economic benefits of using methyl parathion have been determined from field tests on the control of the bollworm, boll weevil and tobacco budworm on cotton; the sorghum midge and greenbug on sorghum; the greenbug on wheat; and the sunflower moth on sunflowers. However, the data is incomplete and should be looked upon with caution.

Methyl parathion gives good control of the bollworm, boll weevil and tobacco budworm. However, the increased resistance of the tobacco budworm to this insecticide in Texas is requiring the use of greater amounts and more frequent applications. Tests at College Station, Texas, have shown a 50-fold increase in the LD_{50} value of methyl parathion to the tobacco budworm between 1964 and 1972; a fivefold increase has been noted in the Rio Grande Valley (Texas) between 1968 and 1972. Increased resistance of the bollworm has also been noted in Texas where the LD_{50} value doubled between 1971 and 1972.

Methyl parathion effectively controls the sorghum midge. However, early uniform planting of the sorghum has reduced the incidence of this pest.

The sorghum greenbug is effectively controlled by methyl parathion. However, under some conditions, the phytotoxicity of this insecticide to sorghum can adversely affect yield.

Methyl parathion has proven to be very effective for control of greenbugs on wheat crops. Its use has resulted in significant yield increases over untreated plots.

The sunflower moth, a significant pest attacking sunflower seeds, is effectively controlled by methyl parathion; multiple applications at the proper times increased yields substantially.

The ranges of economic benefit from the use of methyl parathion on major crops are summarized as follows:

	Economic benefit (loss)($/acre)	
Crop pest	Lowest yield*	Highest yield
Cotton (bollworm, boll weevil, and tobacco budworm)	(30.20)	653.20
Sorghum (midge)	(8.40)	68.30
Sorghum (greenbug)	(13.70)	13.10
Wheat (greenbug)	10.60	19.10
Sunflower (sunflower moth)	(2.60)	57.90

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* Data in parentheses are negative values.

PART II. INITIAL SCIENTIFIC REVIEW

SUBPART A. CHEMISTRY

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This section of the scientific review of methyl parathion contains a review of available data on its chemistry and presence in foods. Seven subject areas have been examined:

1. Synthesis and Production Technology,
2. Physical Properties,
3. Composition and Formulation,
4. Chemical Properties, Degradation Reactions and Decomposition Processes,
5. Occurrence of Methyl Parathion Residues in Food and Feed Commodities,
6. Acceptable Daily Intake,
7. Tolerances, and

The section summarises rather than interprets scientific data reviewed.

Synthesis and Production Technology

The chemical production processes used for methyl parathion and parathion manufacture are almost identical. The only difference is in the alcohol (methanol or ethanol) used in the initial reaction (with phosphorus pentasulfide). The production equipment can be used for producing either of these compounds, and in most cases the same equipment has been used for the manufacture of both products.

The following lists known manufacturers and production levels of methyl parathion.

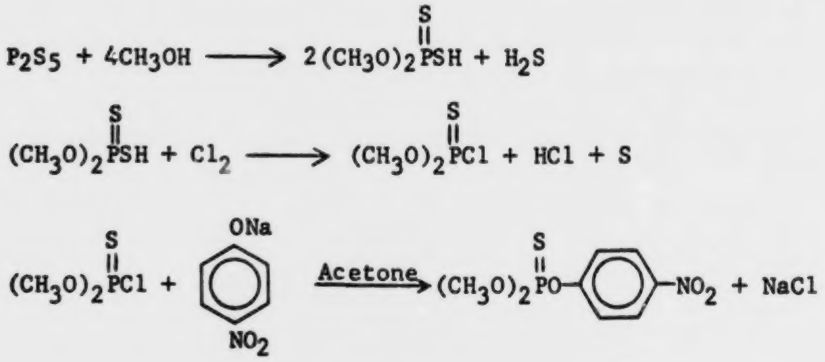
Manufacturer and plant location	Plant capacity[a] (million lb/year)	Estimated 1972 methyl parathion production (million lb)
Monsanto Company, Anniston, Alabama	50	25
Stauffer Chemical Company, Mount Pleasant, Tennessee	30	15
Kerr-McGee Chemical Corporation, Hamilton, Mississippi[b]	9	7
Los Angeles, California	3	0.5
Velsicol Chemical Corporation, Bayport, Texas	10	3.5
Total	102	51.0

Source: MRI estimates.

[a] Plant capacity is stated for methyl parathion plus (ethyl) parathion.

[b] The Kerr-McGee plant at Los Angeles discontinued production after 1972.

Three reactions are involved in the synthesis of methyl parathion:



$$P_2S_5 + 4CH_3OH \longrightarrow 2(CH_3O)_2\overset{\overset{S}{\|}}{P}SH + H_2S \qquad (1)$$

$$(CH_3O)_2\overset{\overset{S}{\|}}{P}SH + Cl_2 \longrightarrow (CH_3O)_2\overset{\overset{S}{\|}}{P}Cl + HCl + S \qquad (2)$$

In the first two reactions the intermediate dimethyl phosphorothionochloridate is produced. This intermediate may be produced on site or elsewhere, or can be purchased from another manufacturer.

One of the most detailed accounts of methyl parathion manufacture is described in a 1953 U.S. patent (Schrader, 1953[1]). According to Schrader, the exothermic third reaction is performed at 80 to 100°C. However, in a patent by Dvornikoff et at. (1953),[2] it is preferred to operate at a much lower temperature of from -10 to +10°C. The reaction is performed at atmospheric pressure and requires a reaction time of 5 hr at 80 to 95°C, but about 18 hr if performed at 0°C.

The reaction is conducted in the liquid phase. One of various organic solvents may be present. An alcoholic medium is specified by Dvornikoff et al. (1953). However, an inert solvent such as benzene or chlorobenzene is preferred by Schrader (1953). Monsanto apparently employs acetone as the solvent.

Copper powder may be used as a catalyst or the reaction may simply be conducted in a copper reaction vessel, thereby shortening reaction time appreciably. A small amount of potassium bromide can be used as an effective co-catalyst. Aliphatic amine catalysts were cited for use in this reaction by Toy et al. (1949).[3] Concentrations of at least 0.25% of materials such as triethyl amine, tributyl amine, N-ethyl morpholine and hexamethylene tetramine may be used.

The reaction is carried out in a stirred, jacketed vessel. Although the reaction is conducted at essentially atmospheric pressure, closed vessels must be used because by-product gases are both toxic and odorous.

The yield of methyl parathion is 90% or higher. The reaction product mixture may be pumped through a precoated filter to remove gummy impurities. The filtrate may then be separated into aqueous and oily layers. The lower oily layer may then be washed with a dilute sodium

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1/ Schrader, G. (to Farbenfabriken Bayer), U.S. Patent No. 2,624,745 (6 January 1953).

2/ Dvornikoff, M. N., et al. (to Monsanto Chemical Company), U.S. Patent No. 2,663,721 (22 December 1953).

3/ Toy, A. D. F. et al. (to Victor Chemical Works), U.S. Patent No. 2,471,464 (31 May 1949).

carbonate solution, then with water; it may then be steam distilled to remove by-product trimethyl thiophosphate. After cooling and settling, the organic layer can be dried by heating under vacuum to give the final product.

Monsanto produces methyl parathion by batch processes in equipment dedicated to methyl and ethyl parathion production. Two of the raw materials are produced on site and the rest are received by rail. A production schematic is shown in Figure 1. Raw materials and by-products from the manufacture of methyl parathion are summarized in Table 1.

Stauffer's method of producing methyl parathion is believed to be similar to Monsanto's.

No information is available concerning production methods at the Kerr-McGee methyl parathion plant. The plant at Hamilton produces neither P_2S_5 nor the p-nitrophenol.

Physical Properties

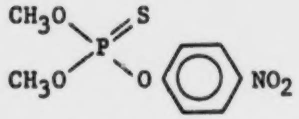
Chemical Name: O,O-dimethyl O-p-nitrophenyl phosphorothioate

Common Name: Methyl parathion

Trade Names: Dalf, Folidol M, Metron, Nitrox 80, Partron M, Tekwaisa, E 601, Metaphor, Folidol 80, Wofatox

Pesticide Class: Broad-spectrum nonsystemic insecticide; organophosphate

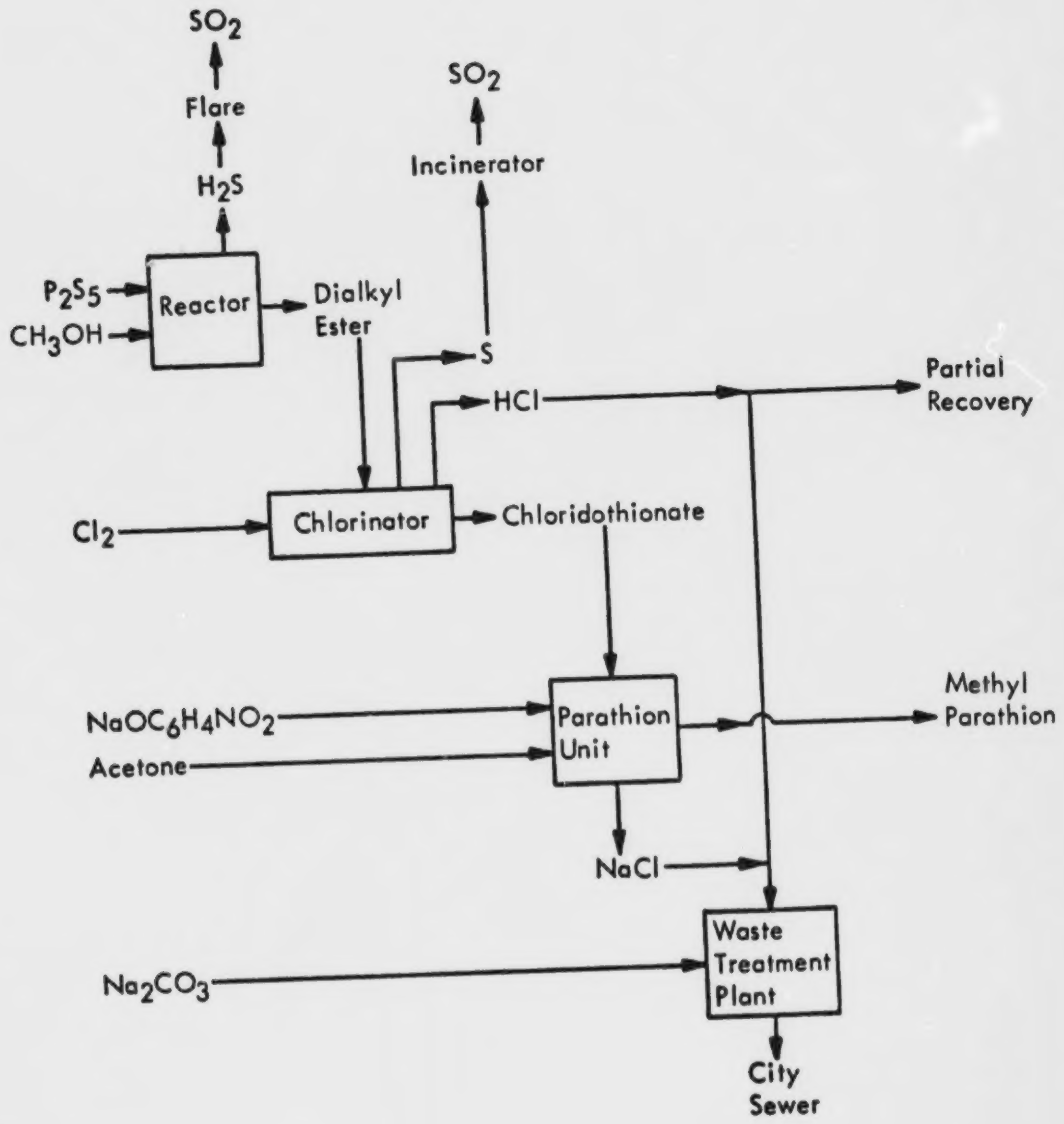
Structural Formula:



Empirical Formula: $C_8H_{10}O_5$ NPS

Molecular Weight: 263.23

Analysis: C, 36.50%; H, 3.83%; N, 5.32%; O, 30.39%; P, 11.77%; S, 12.18%.



Source: Lawless, E. W., and T. L. Ferguson of Midwest Research Institute, and R. von Rümker of RvR Consultants, The Pollution Potential in Pesticide Manufacturing, for Environmental Protection Agency, Contract No. 68-01-0142 (January 1972).

Figure 1. Production schematic for methyl parathion.

Table 1. RAW MATERIALS AND BY-PRODUCTS IN THE MANUFACTURE OF METHYL PARATHION

Raw Materials

	Material	Received From	Received By	Storage	Remarks
1.	P_2S_5	On-site	Tote bins	Tote bins	
2.	Cl_2	Louisiana	Rail, tanks	Tank cars	Vented to production system
3.	CH_3OH	Louisiana	Rail, tanks		
4.	$NaOC_6H_4NO_2$	On-site		Tank	
5.	Acetone	Southwest	Rail, tanks		
6.	Soda ash	East; middle-west	Rail, tanks	Bulk	For waste disposal

Reaction By-Products

	Material	Form	Amount produced (lb/lb AI)	Disposition	Remarks
1.	H_2S	Gas	0.06 calcd.	Flared	SO_2 air pollutant
2.	HCl	Gas	0.12 calcd.	Most recycled	Some to liquid waste
3.	S		0.11 calcd.	Incinerate	SO_2, some H_3PO_4?
4.	NaCl		0.20 calcd.	Biol. waste treatment	Discharged to city sewer

Other Process Wastes and Losses

Material	Form	Amount produced (lb/lb AI)	Disposition	Remarks
Active Ingredient	Aqueous		Liquid waste treatment	< 1 ppm to city sewer
Solvents			Burned	
Other: Organophosphates	Gas liquid		Liquid waste treatment	
p-nitrophenol			Liquid waste treatment	

Source: Lawless, E. W., et al., op. cit. (1972).

Physical State and Melting Point:

(Collaborative International Pesticide Analytical Council (CIPAC), 1970[1])

Pure: White crystalline solid, m.p. 35 to 36°C
Technical: Light to brown liquid, crystallizing about 29°C

(Martin, 1971[2])

Pure: White crystalline powder, m.p. 35 to 36°C
Technical: Light to dark tan liquid, crystallizing about 29°C

(Strecher, 1968[3])

Pure: m.p. 37 to 38°C

(Monsanto[4])

Technical: 80% solution in xylene, garlic-like odor, 18.3°C

(Stauffer, 1969[5])

Technical: 80% solution in xylene, brown liquid, crystallization temperature 18°C

Boiling Point: Thermally unstable, cannot be heated to normal boiling point. Do not heat above 55°C (131°F).

Vapor Pressure (pure): 0.97×10^{-5} mm Hg at 20°C

Specific Gravity: Pure: 1.358 at 20°C
Technical (80% in xylene): 1.22 at 20°C

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[1] Collaborative International Pesticide Analytical Council, "Analysis of Technical and Formulated Pesticides," CIPAC Handbook, 1 (1970).

[2] Martin, H., Pesticide Manual, British Crop Protection Council, Second Edition (1971).

[3] Strecher, P. G., Ed., The Merck Index, Eighth Edition, Merck and Company, Rahway, New Jersey (1968).

[4] Monsanto Company, Agricultural Division, "Parathion, Methyl Parathion," Technical Bulletin No. AG-1b, St. Louis, Missouri (undated).

[5] Stauffer Chemical Company, Methyl Parathion Technical Bulletin (October 1969).

Density: Technical (80% in xylene): 10.2 lb/gal at 20°C

Refractive Index (pure): $n_D^{25} = 1.5367$

$n_D^{35} = 1.5515$

Viscosity (80% in xylene): 6 cp at 25°C

Solubility: Water at 25°C--55 to 60 ppm at 25°C. Slightly soluble in light petroleum and mineral oils; soluble in most other organic solvents; slightly soluble in lipids and fats.

Flash Point (tag open cup): 46°C (80% solution in xylene)

Volatility (pure): 0.14 mg/m^3

Composition and Formulation

The most common formulations of methyl parathion are emulsifiable concentrates (2 to 7 lb/gal) and dusts. Some suggested emulsifiable concentrates are presented in Table 2.

Stable field strength dusts can be prepared from stabilized concentrates made with attapulgite or nonswelling montmorillonite clay. In addition, an extender of pyrophyllite or kaolin can be used in combination with treated calcium carbonate. Direct impregnation, using one of the above combinations of diluents, produces equally stable field strength dusts.

A 20% or 25% stabilized methyl parathion dust concentrate, suitable for further letdown, can be formulated with the following composition:

Ingredients	20% (lb)	25% (lb)
Attapulgite or montmorillonite clay (nonswelling)	74.75	68.5
Methyl parathion (stabilized)	25.25	31.5
Total	100.00	100.0

Table 2. SUGGESTED FORMULATIONS FOR METHYL PARATHION EMULSIFIABLE CONCENTRATES

Ingredients	% by Wt	Lb/Gal
	2 lb/gal	
Methyl parathion (80%)	31.22	2.500[a]
Xylene	63.78	5.107
Emulsifier	5.00	0.400
	100.00	8.007
	4 lb/gal	
Methyl parathion (80%)	57.05	5.000[b]
Xylene	37.95	3.326
Emulsifier	5.00	0.438
	100.00	8.764
	6 lb/gal	
Methyl parathion (80%)	78.41	7.500[c]
Xylene	14.09	1.348
Emulsifier	7.50	0.717
	100.00	9.565
	7 lb/gal	
Methyl parathion (80%)	87.90	8.750[d]
Xylene	4.10	0.408
Emulsifier	8.00	0.796
	100.00	9.954

Source: Monsanto Technical Bulletin No. AG-1b

[a] Equivalent to 2.0 lb of 100% methyl parathion
Specific Gravity at 25/15.6°C. 0.9609
Solution Point, °C. -13

[b] Equivalent to 4.0 lb of 100% methyl parathion
Specific Gravity at 25/15.6°C. 1.0517
Solution Point, °C. -0.5

[c] Equivalent to 6.0 lb of 100% methyl parathion
Specific Gravity at 25/15.6°C. 1.1478
Solution Point, °C. +11

[d] Equivalent to 7 lb of 100% methyl parathion
Specific Gravity at 25/15.6°C. 1.1945
Solution Point, °C. 14.5°

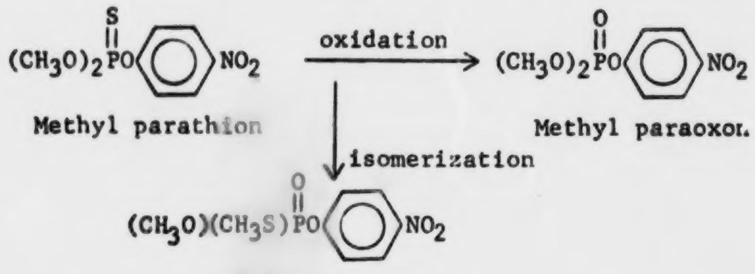
Typical field strength dusts containing 1 to 5% stabilized methyl parathion can be formulated with the following compositions (for approximately 100 lb):

Ingredients	Amount (lb)
Attapulgite or montmorillonite clay (nonswelling)	25
Pyrophyllite talc or kaolin clay	35
Calcium carbonate (treated)	35
Methyl parathion (stabilized)	1.31-6.31

Chemical Properties, Degradation Reactions and Decomposition Processes

The chemical reactions of methyl parathion and parathion are very similar. However, much of the chemistry has been investigated using the ethyl isomer, parathion.

Methyl parathion is a specific chemical compound, O,O-dimethyl O-p-nitrophenyl phosphorothioate (Chemical Abstracts nomenclature).* The biological effects of methyl parathion are intimately associated with two other compounds, methyl paraoxon (O,O-dimethyl O-p-nitrophenyl phosphate) and a thiolate isomer of methyl parathion (O,S-dimethyl O-p-nitrophenyl phosphorothiolate). As indicated below, these compounds are formed by oxidation and isomerization of methyl parathion.



Methyl parathion

Methyl paraoxon

Thiolate isomer

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* Parathion is the corresponding ethyl ester, O,O-diethyl O-p-nitrophenyl phosphorothioate.

Compounds of this kind are toxic primarily because they react with acetylcholinesterase. The toxicity of methyl parathion depends entirely upon its oxidative conversion in vivo to methyl paraoxon. Methyl parathion is oxidized enzymically to methyl paraoxon, but can also be oxidized to methyl paraoxon by the chemical action of atmospheric oxygen. The atmospheric oxidation is accelerated by ultraviolet radiation.

The Effect of Sunlight and Ultraviolet Radiation - When methyl parathion was exposed to both UV radiation and sunlight only methyl paraoxon was identified (Koivistoinen and Meriläinen, 1962[1/]).

Hydrolysis - Hydrolysis is perhaps the most important degradation reaction of organic phosphorus insecticides, because hydrolysis virtually destroys all insecticidal activity.

The extent of hydrolytic stability is, in general, related to the electronic characteristics of the substituents attached to the phosphorus atom. Thus, the replacement of a phosphorus-bound oxygen atom with a sulfur atom usually increases the resistance of the molecule to hydrolysis. This fact probably accounts for the fact that the chemical structures of most commercial organophosphate insecticides contain sulfur.

In methyl parathion (and in parathion), there are three potential groups which may be hydrolyzed from the phosphorus portion of the molecule. However, only one, the *p*-nitrophenol group, is of practical significance; the hydrolysis of the most labile group greatly increases the hydrolytic stability of the remaining groups.

The rate of hydrolysis of methyl parathion is considerably faster than that of parathion; at pH 1 to 5, 50% is hydrolyzed in 175 days at 20°C (compared to 690 days for parathion under the same conditions). The rate of hydrolysis of methyl parathion in alkaline medium is even faster; only 32 min are required for 50% hydrolysis in 1N NaOH at 15°C (Melnikov, 1971;[2/] Lawless et al., 1973[3/]).

[1/] Koivistoinen, P., and M. Meriläinen, "Paper Chromatographic Studies on the Effect of Ultraviolet Light on Parathion and Its Derivatives," Acta Agr. Scand., 12:267-276 (1962).

[2/] Melnikov, N. N., Chemistry of Pesticides, Springer-Verlag, New York (1971).

[3/] Lawless, E. W., T. L. Ferguson, and A. F. Meiners of Midwest Research Institute, Methods for the Disposal of Spilled and Unused Pesticides (draft), for Environmental Protection Agency, Contract No. 68-01-0098 (1973).

The Effect of Heat - Thermal isomerization has been demonstrated for methyl parathion; 91% isomerization resulted within 6.5 hr at 150°C (Metcalf and March, 1953[1]). Only one decomposition product, the S-methyl ester (thiolate isomer) was identified. (See Figure 2.)

Heating most insecticidal organophosphates above 200°C results in decomposition. With methyl parathion, isomerization to the S-methyl isomer is followed by the generation of dimethyl sulfide and sulfur dioxide and a mixture of poly(aryl metaphosphates), which decompose to a carbonaceous residue that is explosive (McPherson and Johnson, 1956[2]). Methyl parathion may also decompose at temperatures between 65 and 115°C. However, the time for decomposition is measured in days rather than hours (Dauterman, 1971[3]).

According to the National Agricultural Chemicals Association (1968),[4] methyl parathion may explode at 120°C. For an adequate safety margin, methyl parathion should not be heated above 55°C. When heated to decomposition, methyl parathion emits highly toxic fumes of nitrogen oxides, phosphorus, and sulfur compounds (National Agricultural Chemicals Association, 1968).

The hazards from fires involving organic phosphorus insecticides have been investigated and it was concluded that most of the insecticide is destroyed by decomposition before it can evaporate, and over 90% of the evaporating insecticide is destroyed by the flames (Smith and Ledbetter, 1971[5]).

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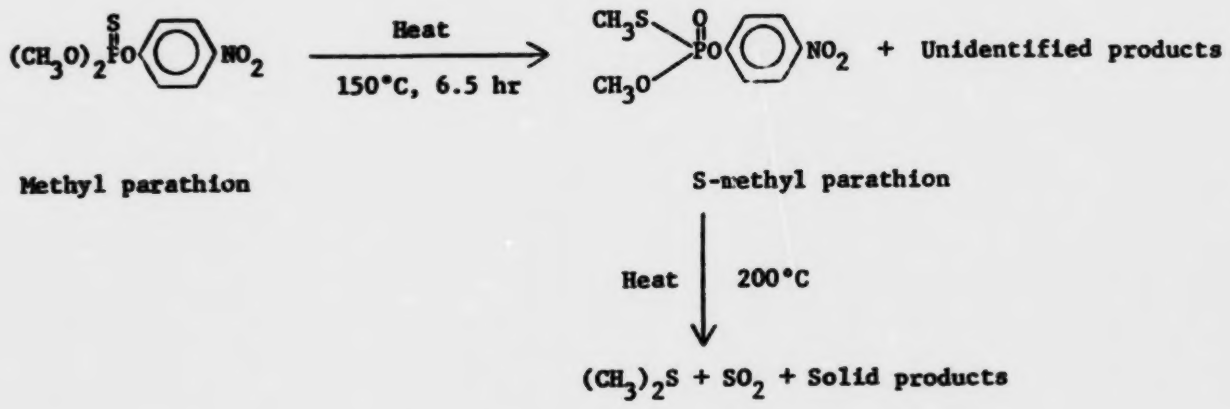
[1] Metcalf, R. L., and R. B. March, "The Isomerization of Organic Thiophosphate Insecticides," J. Econ. Entomol., 46:288-294 (April 1953).

[2] McPherson, J. B., Jr., and G. A. Johnson, "Thermal Decomposition of Some Phosphorothioate Insecticides," J. Agr. Food Chem., 4(1):42-49 (January 1956).

[3] Dauterman, W. C., "Biological and Nonbiological Modifications of Organophosphorus Compounds," Bulletin of the World Health Organization, 44(1-2-3):144 (1971).

[4] National Agricultural Chemicals Association, Safety Guide for Warehousing Parathions, Washington, D.C., 19 pages (1968).

[5] Smith, W. M., Jr., and J. O. Ledbetter, "Hazards from Fires Involving Organophosphorus Insecticides," Amer. Ind. Hyg. Assoc. J., 32(7):468-474 (July 1971).



Adapted from: Metcalf, R. L., and R. B. March, op. cit. (1953); McPherson, J. B., Jr., and G. A. Johnson, op. cit. (1956).

Figure 2. Thermal isomerization of methyl parathion.

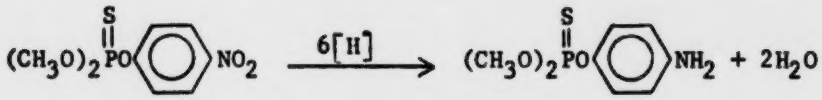
Oxidation - Several chemical oxidizing agents are capable of replacing the sulfur atom in parathion with an oxygen atom. Although no specific references were located which described the oxidation of methyl parathion, it would be expected that the oxidative reactions of methyl parathion would be similar to those of parathion.

Koivistoinen and Meriläinen (1962) showed that when parathion was exposed as a thin film, trace amounts of paraoxon were formed even in the absence of light.

A recent publication (Gunther et al., 1970[1]) pointed out that parathion can be rapidly and conveniently oxidized to paraoxon by means of ozone (20 to 40% conversion).

Gomma and Faust (1971)[2] noted that chlorine or potassium permanganate would convert dilute solutions of parathion in water to paraoxon.

Reduction - Reducing agents (for example, metals in acid medium) convert methyl parathion to the corresponding amino compound (Melnikov, 1971).



The product, O,O-dimethyl O-4-aminophenyl thiophosphate, is nontoxic to animals and does not have an insecticidal effect.

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[1] Gunther, F. A., D. E. Ott, and M. Ittig, "The Oxidation of Parathion to Paraoxon. II. By Use of Ozone," *Bull. Environ. Contam. Toxicol.*, 5(1):87-94 (1970).

[2] Gomma, H. M., and S. D. Faust, "Chemical Oxidation of Organic Pesticides in Aquatic Environments," Paper No. 48, 161st American Chemical Society Meeting, Los Angeles, California (29 March-12 April 1971).

Analytical Methods

This subsection reviews methyl parathion analytical methods and the most significant of many primary information sources on the methods. The following information sources are described: (1) The Pesticide Analytical Manual (PAM), Vols. I, II,[1] (2) Official Methods of Analysis of the Association of Official Analytical Chemists,[2] (3) Analytical Methods for Pesticides and Plant Growth Regulators.[3]

The Pesticide Analytical Manual - The "Pesticide Analytical Manual" (PAM), published by the Food and Drug Administration, provides procedures and methods used by the FDA laboratories to examine food samples for the presence of pesticide residues. The PAM is published in two volumes. Volume I contains procedures for multi-residue methods (for samples of unknown history which may contain more than one pesticide). Volume II contains analytical methods used for specific pesticide residues and for specific foods.

Official Methods of Analysis of the Association of Official Analytical Chemists - The Association of Official Analytical Chemists (AOAC) publishes an authoritative methods manual published about every 5 years. The manual is designed to provide both research and regulatory chemists with reliable methods of analysis. The reliability of the methods must be demonstrated by a published study showing the reproducibility of the method by professional analysts.

When an AOAC method is adopted for the first time it is published as "Official First Action." This designation serves notice that final adoption is pending, and permits an opportunity for any further study that may be deemed appropriate.

Methods that have performed successfully for at least 1 year are raised to the status of "Official Final Action."

A few methods are adopted as "Procedures." Such methods are generally sorting or screening methods or well-established types of examinations, or auxiliary operations, such as sampling or preparation of a sample, which may not have been subjected to collaborative study.

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[1] U.S. Department of Health, Education, and Welfare, Food and Drug Administration, Pesticide Analytical Manual, 2 vols. (1971).

[2] Association of Official Analytical Chemists, Official Methods of Analysis of the Association of Official Analytical Chemists, 11th ed., Washington, D.C. (1970).

[3] Zweig, G., and J. Sherma, Analytical Methods for Pesticides and Plant Growth Regulators, Vol VI: Gas Chromatographic Analysis, Academic Press, New York (1972).

Analytical Methods for Pesticides and Plant Growth Regulators, Volume VI, Gas Chromatographic Analysis - Chapter 6 of this text (Zweig and Sherma, 1972) consists of an extensive and detailed review of specific and multi-residue analytical methods for organophosphate pesticides. This reference provides important information not available in AOAC's "Methods of Analysis" or the PAM such as (1) a comparison of nine procedures for extracting phosphorus insecticides and their metabolites from field-treated crops, (2) a review of procedures for extracting organophosphate pesticides from water samples, (3) a review of insecticide recoveries from vegetables, (4) a review of various clean-up procedures, (5) a description of various detectors, (6) extensive data comparing the relative retention times of various pesticides on various column materials, and (7) a review of the sensitivity of various gas chromatographic systems.

Multi-Residue Methods -

Multi-residue methods for methyl parathion are described in the AOAC's methods manual and PAM, Volume I. Zweig and Sherma (1972) have compiled a detailed review of gas chromatographic residue analyses.

AOAC Methods - One of the AOAC methods,[1/] a general method for "chlorinated and phosphated pesticides," is an "Official First Action" and applies only to apples and lettuce. A second AOAC multi-residue method[2/] applies only "phosphated pesticides" (in kale, endive, carrots, lettuce, apples, potatoes, and strawberries). This second method is also an "Official First Action" and involved a sweep codistillation cleanup for the organophosphate residues. (The cleanup is not adequate for electron capture detectors; KCl thermionic detectors must be employed.) Also described in AOAC methods manual[3/] is a single sweep oscillographic-polarographic confirmation method.

The following AOAC multi-residue method is used for chlorinated and phosphated pesticides: A thoroughly mixed sample is extracted with acetonitrile. Aliquots of the acetonitrile solution are diluted with water and the pesticide residues are extracted into petroleum ether. The residues are purified by chromatography on a Florisil column and are eluted from the column with mixtures of petroleum and ethyl ethers. The first eluate, (6% ethyl ether in petroleum ether) contains some chlorinated pesticides and some phosphated pesticides. However, methyl parathion and parathion (and diazinon) are obtained in a second eluate (15% ethyl ether in petroleum ether). A third eluate (50% ethyl ether in petroleum ether) contains malathion. The eluates are concentrated, and the residues are determined by gas chromatography and identified by combinations of gas, thin-layer, or paper chromatography.

PAM Procedures - The PAM multi-residue methods (PAM, 1971) apply to the wide variety of foods tested by the FDA. However, the multi-residue methods

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[1/] AOAC, op. cit., p. 475 (1970).
[2/] AOAC, op. cit., p. 484 (1970).
[3/] AOAC, op. cit., p. 487 (1970).

are not capable of detecting and measuring all pesticides. Analytical schemes used in the detection of methyl parathion are shown in Figures 3 and 4. The various parts of the schemes shown in Figures 3 and 4 are outlined in detail in the PAM. (The numbers refer to the chemical numbering system of PAM; the chapter numbers also refer to PAM.)

Methyl parathion is more than 80% recovered in the 15% ethyl ether in petroleum ether fraction from the Florisil column. Over 80% recovery is achieved from both fatty and nonfatty foods.

Relative retention times of methyl parathion are presented below for various column packings; the corresponding response for various detectors is also indicated.

Electron Capture Detector

Column packing	Retention time relative to aldrin (ratio)	Response (ng for 1/2 FSD* at 1 x 10^{-9} AFS**)
10% DC 200 on Gas-Chrom Q (or Anakrom Q)	0.68	2-3
15% QF-1, 10% DC 200 on Gas-Chrom Q	1.42	2.5

Sulfur Detector

Column packing	Retention time relative to sulphenone (ratio)	Response (µg for 112 FSD* 64 ohms)
10% DC 200 on Gas-Chrom Q	0.60	2
15% QF-1, 10% DC 200 on Gas-Chrom Q	0.55	2

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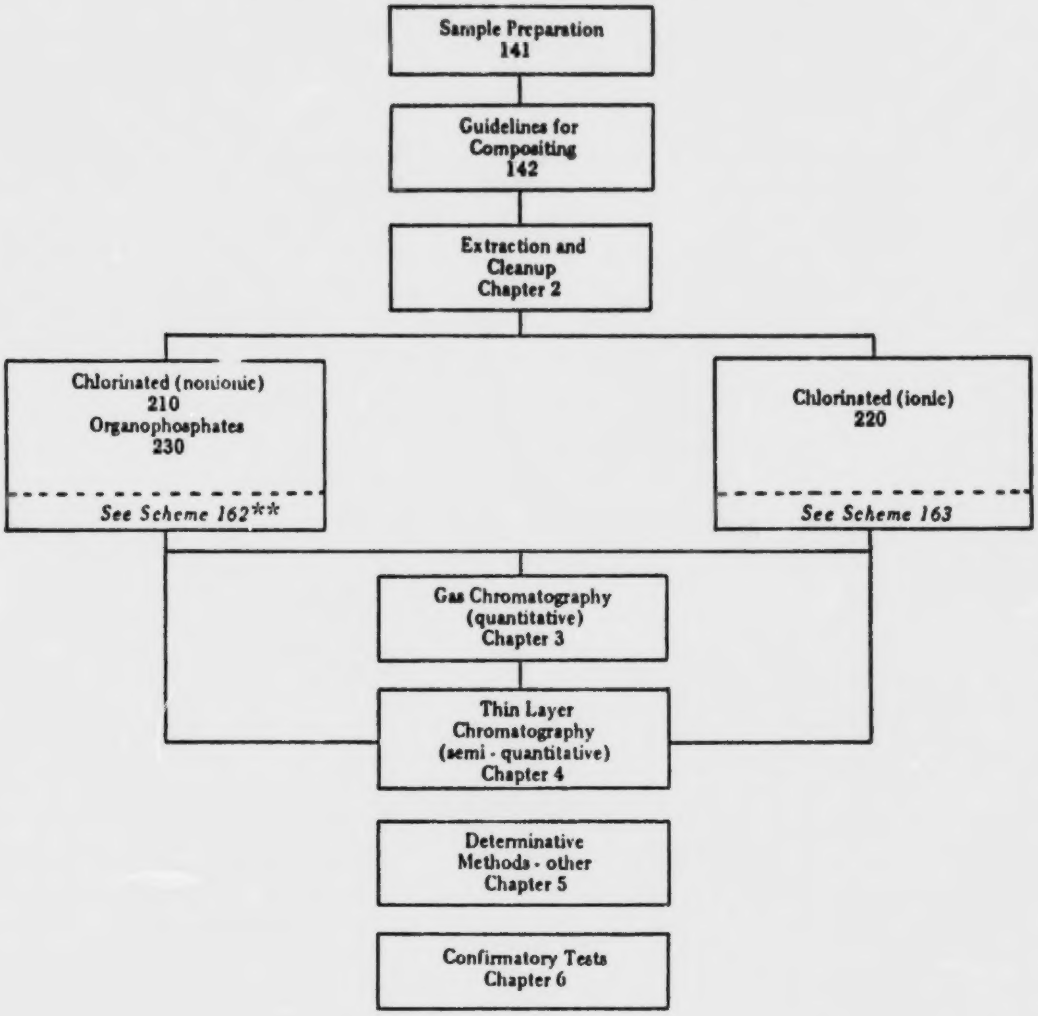
* FSD = Full scale deflection.

** AFS = Amps, full scale.

Figure 3

GENERAL SCHEME FOR MULTIPLE RESIDUES*


Sample Preparation 141
Guidelines for Compositing 142
Extraction and Cleanup Chapter 2
Chlorinated (nonionic) 210 Organophosphates 230
See Scheme 162**
Chlorinated (ionic) 220
See Scheme 163
Gas Chromatography (quantitative) Chapter 3
Thin Layer Chromatography (semi - quantitative) Chapter 4
Determinative Methods - other Chapter 5
Confirmatory Tests Chapter 6

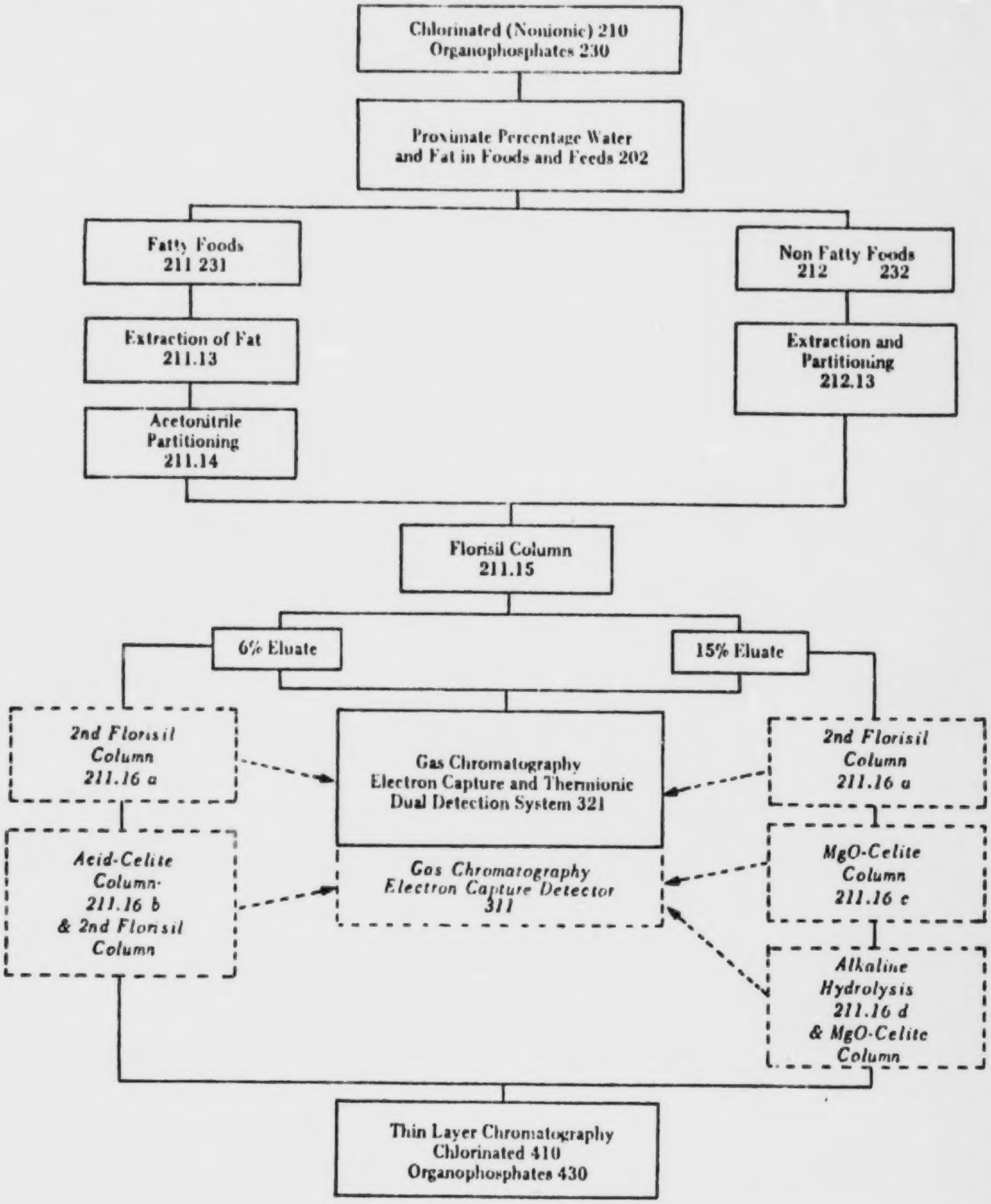
* The numbers refer to the decimal numbering system of PAM. Chapter numbers also refer to PAM.

** Scheme 162 is presented in Figure 2.

Source: PAM, 1971.

Figure 4

ANALYTICAL SCHEME FOR CHLORINATED (NONIONIC) AND ORGANOPHOSPHATE RESIDUES*


Chlorinated (Nonionic) 210
Organophosphates 230
Proximate Percentage Water and Fat in Foods and Feeds 202
Fatty Foods 211 231
Non Fatty Foods 212 232
Extraction of Fat 211.13
Extraction and Partitioning 212.13
Acetonitrile Partitioning 211.14
Florisil Column 211.15
6% Eluate
15% Eluate
2nd Florisil Column 211.16 a
Gas Chromatography Electron Capture and Thermionic Dual Detection System 321
2nd Florisil Column 211.16 a
Acid-Celite Column 211.16 b & 2nd Florisil Column
Gas Chromatography Electron Capture Detector 311
MgO-Celite Column 211.16 c
Alkaline Hydrolysis 211.16 d & MgO-Celite Column
Thin Layer Chromatography
Chlorinated 410
Organophosphates 430

* The numbers refer to the decimal numbering system of PAM. The primary analytical scheme is in bold type. Additional cleanup and/or quantitation schemes are in italics.

Source: PAM, 1971.

Potassium Chloride Thermionic Detector

Column packing	Retention time relative to parathion (ratio)	Response (mg for 1/2 FSD*)
10% DC-200 on Chromosorb W-HP (or Gas Chrom Q)	0.7	2.5
15% QF-1 + 10% DC 200 on Chromosorb W-HP (or Gas Chrom Q)	0.76	2

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* FSD = Full scale deflection.
** AFS = Amps, full scale.

The PAM does not provide response data for flame photometric detectors. However, this type of detector is now widely used for the analysis of organophosphate residues, primarily because of the high degree of specificity in detecting phosphorus compounds. A review of these and other detectors is provided by Zweig and Sherma (1972)[1/].

Residue Analysis Principles -

Both AOAC methods manual and PAM (Vol. II) describe methods for the specific analysis of parathion residues. The PAM methods are stated to be applicable to methyl parathion, but no similar statement was found in AOAC (1970). However, an examination of the AOAC methods reveals that they should be applicable to both parathion and methyl parathion. Zweig and Sherma[2/] have provided a review of specific residue analytical methods for methyl parathion.

AOAC Method (Official Final Action) - According to the AOAC method[3/] for specific analysis of parathion (and, presumably, methyl parathion) residues, parathion is extracted with benzene or 2-propanol-benzene, and the strip solution is clarified. Parathion is brought into aqueous solution and simultaneously reduced to its amine with zinc and hydrochloric acid. The

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[1/] Zweig and Sherma, op. cit., p. 205 (1972).
[2/] Zweig and Sherma, op. cit., p. 445 (1972).
[3/] AOAC, op. cit., p. 508 (1970).

amine is diazotized and coupled with N-(1-naphthyl)-ethylenediamine to form a colored compound which is analyzed spectrophotometrically.

The practical working range for the Beckman DU spectrophotometer is 0 to 200 μg parathion.

The method has been employed for parathion residues in a wide variety of fruits and vegetables.

PAM Methods - PAM (1967) lists three methods for specific residue analysis. The first two methods have been "tested in varying degrees and are considered reliable without further validation for the product applications indicated." The third method has not been "thoroughly tested through interlaboratory studies."

The First Method - This method refers to the PAM procedure for organophosphate (PAM, 1971); This procedure is summarized in the "Multi-Residue Methods" section.

The Second Method - This method refers to an AOAC procedure (AOAC, 1965[1]); a summary of an updated AOAC method is described in the preceding section.

According to PAM (Volume II), the AOAC method is generally applicable to all products excluding fats and oils.

The sensitivity is 0.2 ppm.

Cole crops develop an interfering pink color, and blank values as high as 1 ppm and over are not uncommon with some of these crops (Rolston and Walton, 1963[2]).

Aniline and some aniline analogues interfere. Methyl anthranilate, which is found in grapes and citrus fruits, interferes. The amount of methyl anthranilate and hence the extent of interference differs with the maturity and variety of the fruit. (Taschenberg and Avens, 1960[3]).

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[1] AOAC, op. cit., (1965).

[2] Rolston, L. H. and R. R. Walton, "Parathion Residues in Greens," J. Econ. Entomol., 56:169-172 (1963).

[3] Taschenberg, E. F. and A. W. Avens, "Parathion and EPN Residue Studies on Concord Grapes," J. Econ. Entomol., 53:441-445 (1960).

Taschenberg and Avens used the procedure of Averell and Norris (1948)[1] except that the benzene solution is repeatedly washed with 10% HCl to remove interference. Alternatively, methyl parathion can be determined by difference: the anthranilate is determined before the methyl parathion is reduced and then both compounds are measured together after reduction. The difference in results represents the methyl parathion.

Decomposed leafy vegetables contain decomposition products which are not removed by the clean-up procedure and which yield false results. (M. L. Dow, FDA, private communication to PAM editors, October 1961).

The Third Method - The third method is a polarographic procedure which can be used as a rapid scanning technique (Gajan, 1963[2]). The method has been tested on apples and several vegetables. Parathion quantities of less than 0.1 ppm have been determined. Methyl anthranilate does not interfere. Methyl parathion, EPN, and PCNB give peaks sufficiently close to the parathion peak as to interfere with the determination. Recent studies by the author indicate that the procedure can be extended to fats and oils except olive oil, where interferences have been encountered.

Formulation Analysis Principles -

Formulation analysis procedures for parathion are described in the AOAC methods manual. The procedures should be applicable to methyl parathion although this is not explicitly stated by AOAC. EPA's Technical Service Division, Office of Pesticide Programs has provided additional formulation analysis procedures.

AOAC Methods (Official Final Action) - The two AOAC methods are volumetric (applicable to all forms of technical parathion) and colorimetric (applicable to dusts and wettable powders).

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[1] Averell, P. R. and M. V. Norris, "Estimation of Small Amounts of O,O-diethyl O-(p-nitrophenyl)thiophosphate," Anal. Chem., 20(8): 753-756 (August 1948).

[2] Gajan, R. J., "Applications of Oscillographic Polarography to the Determination of Organophosphorus Pesticides, II. A Rapid Screening Procedure for the Determination of Parathion in Some Fruits and Vegetables," J. Assoc. Off. Agr. Chem., 46(2):216-222 (1963).

The volumetric method[1] involves a potentiometric titration of the parathion amine (produced by reduction with zinc and hydrochloric acid) with sodium nitrite. _p_-Nitrophenol in parathion is initially removed by extraction (aqueous sodium carbonate) and determined by ultraviolet spectrophotometry.

The colorimetric method[2] involves an extraction of parathion with alcohol followed by a hydrolysis of parathion with potassium hydroxide to form potassium _p_-nitrophenate which is determined by ultraviolet spectrophotometry.

EPA Method - In addition to the AOAC formulation methods, the Technical Service Division of EPA employs a high-pressure liquid chromatographic procedure and an infrared spectroscopic procedure for methyl parathion analysis. The procedures are described as follows:[3]

1. The High-Pressure Liquid Chromatographic Method -
    a. Operating Conditions for Liquid Chromatograph - UV detector at 254 mm. Operating conditions must be determined for the individual liquid chromatograph to achieve optimum sensitivity and resolution.
    b. Procedure -
        1. Standard preparation - Weigh 0.1 g methyl parathion standard into a 100 ml volumetric flask, dissolve, and make to volume with methanol.
        2. Sample preparation - Weigh a portion of sample equivalent to 0.1 g methyl parathion into a glass-stoppered flask, add 100 ml methanol, and shake well.

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[1] AOAC, _op. cit._, p. 114 (1970).
[2] AOAC, _op. cit._, p. 115 (1970).
[3] Boynton, R. Warren, TSD, OPP, EPA, Personal Communication to Dr. Alfred Meiners (September, 1974).

c. Determination-- Using a high-pressure liquid syringe, alternately inject three 5 µl portions each of standard and sample solutions. Measure the peak area for each peak and calculate the average for both standard and sample. Adjustments in attenuation or amount injected may have to be made to gove convenient size peaks.

d. Calculation -

$$\%\ \text{methyl parathion} = \frac{(\text{avg area sample})(\mu\text{l std})(\mu\text{g}/\mu\text{l std})(\text{purity of std})(100)}{(\text{avg area std})(\mu\text{l sample})(\mu\text{g}/\mu\text{l sample})}$$

(This method was developed by Elmer H. Hayes of the Beltsville Chemistry Laboratory, Technical Service Division, Chemical and Biological Investigations.)

2. Infrared Spectroscopic Procedure -

a. Preparation of Standard - Weight 0.100 g standard methyl parathion into a 10-ml volumetric flask. Dissolve and make to volume with carbon disulfide. Add a small amount of anhydrous sodium sulfate, shake, and allow to settle.

b. Preparation of Sample - Weigh a portion of sample equivalent to 0.200 g of methyl parathion into a 250 to 300 ml glass-stoppered Erlenmeyer flask. Add 100 ml acetone and shake on mechanical shaker for 1 hr. If necessary, centrifuge to clarify. Pipette 50 ml of the clear solution into a 125-ml standard taper flask and evaporate on a rotary evaporator. Add 5 ml carbon disulfide and evaporate again to remove all traces of acetone. Transfer quantitatively with carbon disulfide to a 10-ml volumetric flask, make to volume and add a small amount of anhydrous sodium sulfate, shake, and allow to settle.

c. IR Determination - Using the optimum quantitative settings for the particular IR instrument being used, scan both the standard and the sample solutions using the same 0.2-mm NaCl or KBr cell in the sample beam. Compensate with carbon disulfide in a matched 0.2-mm cell in the reference beam. For quantitative results scan from about 7.0 µ to 9.0 µ (1425 cm^{-1} to 1110 cm^{-1}). For qualitative comparison run a full scan.

d. Calculation - Measure the absorbance of both standard and sample using the peak at 8.10 µ (1235 cm^{-1}) and a baseline from 7.85 µ to 8.35 µ (1275 cm^{-1} to 1195 cm^{-1}). Calculate the percent methyl parathion as follows:

$$\%\ \text{methyl parathion} = \frac{(\text{abs. sample})(\text{wt. std.})(\text{purity of std.})(1/10)(100)}{(\text{abs. std.})(\text{wt.sample})(50/100)(1/10)}$$

Occurrence of Methyl Parathion Residues in Food and Feed Commodities -

The Food and Drug Administration (FDA) monitors pesticide residues in the nation's food supply through two programs. One program, commonly known as the "total diet program," involves the examination of food ready to be eaten. This investigation measures the amount of pesticide chemicals found in a high-consumption varied diet. The samples are collected in retail markets and prepared for consumption before analysis. The other program involves the examination of large numbers of samples, obtained when lots are shipped in interstate commerce, to determine compliance with established tolerances. These analyses are complimented by observations and investigations in the growing areas to determine the actual practices being followed in the use of pesticide chemicals.

A majority of the samples collected in these programs are categorized as "objective" samples. Objective samples are those collected where there is no suspicion of excessive residues or misuse of the pesticide chemicals. All samples of imported foods and fish are categorized as "objective" samples even though there may be reason to believe excessive residues may be found on successive lots of these food categories.

Market-basket samples for the total diet studies are purchased from retail stores, bimonthly, in five regions of the United States. A shopping guide totaling 117 foods for all regions is used, but not all foods are represented in all regions because of differences in regional dietary patterns. The food items are separated into 12 classes of similar foods and prepared for consumption by dietitians in institutional kitchens. After preparation, the food items are composited into 12 classes of similar foods (e.g., dairy products; meat, fish and poultry; legume vegetables; and garden fruits) for more reliable analysis and to minimize the dilution factor. Each class in each sample is a "composite." The food items and the proportion of each used in the study was developed in cooperation with the Household Economics Research Division, U.S. Department of Agriculture, and represents the high-consumption level of a 16- to 19-year-old male. Each sample represents a 2-week supply of food.

Surveillance samples are generally collected at major harvesting and distribution centers throughout the U.S. and examined in 16 FDA district laboratories. Some samples may be collected in the fields immediately prior to harvest. Surveillance samples are not obtained in retail markets. Samples of imported food are collected when offered for entry into the United States.

The results of the FDA analytical studies are tabulated for the following food classes:

Dairy products

Large fruits

Small fruits

Grains and cereals (human)

Leaf and stem vegetables

Vine and ear vegetables

Root vegetables

Beans

Red meat

Poultry

Eggs

Fish

Shellfish

Grains (animal)

Infant and junior foods

Tree nuts

Vegetable oil products

The most recently available analytical data are presented in Table 3, which lists the incidence and ranges of levels of methyl parathion detected in the various food classes. The omission of any food class from the tables indicates that no residues were found.

The available data covers the years 1964 to 1969. Limited data is available for the year 1970 (Corneliussen, 1972[1]) and a complete update on pesticide residue data is expected in the forthcoming September 1974 issue of the Pesticide Monitoring Journal.

Acceptable Daily Intake

The acceptable daily intake (ADI) is defined as the daily intake which, during an entire lifetime, appears to be without appreciable risk on the basis of all known facts at the time of evaluation (Lu, 1973[2]). It is expressed in milligrams of the chemical per kilogram of body weight (mg/kg).

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[1] Corneliussen, P. E., "Residues in Food and Feed: Pesticide Residues in Total Diet Samples (VI)," Pest. Monit. J., 5(4):313-329 (March 1972).

[2] Lu, F. C., "Toxicological Evaluation of Food Additives and Pesticide Residues and Their 'Acceptable Daily Intakes' for Man: The Role of WHO, in Conjunction with FAO," Residue Rev., 45:81-93 (1973).

Table 3. PERCENT DISTRIBUTION OF METHYL PARATHION RESIDUES BY FISCAL YEAR IN DIFFERENT QUANTITATIVE RANGES

	Percent Distribution of Samples							
	Domestic				Imported			
Range PPM	1966-67	1968	1969	Total	1966-67	1968	1969	Total
				Leaf and Stem Vegetables				
No. Samples	5780	2251	1782	9813	35	8	19	62
None found	95.69	91.60	90.85	93.88	100.00	100.00	100.00	100.00
Trace-0.03	1.31	3.78	3.87	2.34	-	-	-	-
0.04-0.10	0.96	2.18	2.19	1.47	-	-	-	-
0.11-0.50	1.73	2.09	2.97	2.04	-	-	-	-
0.51-1.00	0.22	0.31	0.06	0.21	-	-	-	-
1.01-1.50	0.06	0.04	-	0.05	-	-	-	-
1.51-2.00	-	-	-	-	-	-	-	-
Above 2.00	-	-	0.06	0.01	-	-	-	-
				Root Vegetables				
No. Samples	5425	1758	1060	8243	165	66	89	320
None found	99.79	99.43	98.58	99.56	98.78	100.00	98.88	99.06
Trace-0.03	0.09	0.28	0.85	0.23	1.21	-	1.12	0.94
0.04-0.10	0.07	0.11	0.38	0.12	-	-	-	-
0.11-0.50	0.01	0.11	0.19	0.06	-	-	-	-
0.51-1.00	0.01	0.06	-	0.02	-	-	-	-
1.01-1.50	-	-	-	-	-	-	-	-
1.51-2.00	-	-	-	-	-	-	-	-
Above 2.00	-	-	-	-	-	-	-	-

Adapted from Duggan, R. E., G. Q. Lipscomb, E. L. Cox, R. E. Heatwole, and R. C. King, "Pesticide Residue Levels in Foods in the United States from 1 July 1963 to 30 June 1969," Pest. Monit. J., 5(2):73-212 (September 1971).

For methyl parathion the ADI is 0.001 mg/kg. This level was set at the 1968 Joint Meeting of the FAO Committee on Pesticides in Agriculture and the WHO Expert Committee on Pesticide Residues (FAO/WHO, 1969[1/]). A joint meeting is held annually and new evidence is considered which would warrant a change in the ADI of any pesticide. The level for methyl parathion has not been changed through 1971 (FAO/WHO, 1972[2/]).

In making the evaluation, all available research on methyl parathion concerning its biochemical effects, toxicology, and teratology was considered.

Tolerances

U.S. Tolerances - Section 408 of the Food, Drug and Cosmetic Act, as amended, gives procedures for establishing tolerances for pesticide chemicals on raw agricultural commodities. Section 409 applies to food additives, including pesticide chemicals on processed foods. Tolerances are published in the Code of Federal Regulations, Title 40, and in the Federal Register. Tolerances for residues of methyl parathion have not been established per se, but all residue tolerances established for parathion have been declared applicable to methyl parathion. When both methyl parathion and parathion residues are present, the tolerances apply to their combined total. A summary of current tolerances applicable to methyl parathion is presented in Table 4.

According to Lu (1973), U.S. tolerances which are established should not result in the maximum ADI being reached each day. He gives the following reasons:

1. The tolerance reflects the maximum level of residue resulting from good agricultural practice, but this level is often not reached.

2. The tolerance is based on the assumption that the particular pesticide is used on all food in the class in question, and this is rarely the case.

3. Much of the residue will be lost in storage, processing and cooking.

The tolerances are also based upon the entire product as purchased in the market. However, the product, as purchased, may not be entirely consumed.

[1/] FAO/WHO, Food and Agricultural Organization of the United Nations/World Health Organization, "1968 Evaluations of Some Pesticide Residues in Food," The Monographs, Geneva (1969).

[2/] FAO/WHO, Food and Agricultural Organization of the United Nations/World Health Organization, "Pesticide Residues in Food," Report of the 1971 Joint FAO/WHO Meeting on Pesticide Residues, World Health Organization Tech. Rept. Series No. 502, Geneva (1972).

Table 4. SUMMARY OF U.S. TOLERANCES FOR METHYL PARATHION AND/OR PARATHION ON RAW AGRICULTURAL COMMODITIES[a]

ppm	Crop	ppm	Crop	ppm	Crop
0.1(N)	Almonds	1	Endive (escarole)	0.9(1)(N)	Potatoes
1.25	Alfalfa fresh	1	Figs	1	Pumpkins
5	Alfalfa hay	0.1(N)	Filberts	1	Quinces
1	Apples	1	Garlic	1	Radishes (with or with-
1	Apricots	1	Gooseberries		out tops)
1	Artichokes	1	Grapes	1	Radish tops
1	Avocados	1	Grass for forage	0.2	Rape seed
1	Barley	1	Guavas	1	Raspberries
1	Beans	1	Hops	1	Rice
1	Beets (with our without	1	Kale	1	Rutabagas (with or with-
	tops)	1	Kohlrabi		out tops)
1	Beet greens	1	Lettuce	1	Rutabaga tops
1	Blackberries	1	Loganberries	0.5(1)(N)	Rye
1	Blueberries (huckleberries)	1	Mangoes	0.1(1)(N)	Safflower seed
1	Boysenberries	1	Melons	0.1(1)(N)	Sorghum
1	Broccoli	1	Mustard greens	1	Soybean hay
1	Brussel sprouts	0.2	Mustard seed	0.1	Soybeans
1	Cabbage	1	Nectarines	1	Spinach
1	Carrots	1	Oats	1	Squash
1	Cauliflower	1	Okra	1	Strawberries
1	Celery	1	Olives	0.1(1)(N)	Sugar beets
1	Cherries	1	Onions	0.1(1)(N)	Sugar cane
1	Citrus fruits	1	Parsnips (with or	1	Summer squash
1	Clover		without tops)	0.2	Sunflower seed
1	Collards	1	Parsnip greens	0.1(1)(N)	Sweet potatoes
1	Corn	1	Peaches	1	Swiss chard
1	Corn forage	1	Pea forage	1	Tomatoes
0.75	Cottonseed	1	Peanuts	1	Turnips (with or with-
1	Cranberries	1	Pears		out tops)
1	Cucumbers	1	Peas	1	Turnip greens
1	Currants	0.1(1)(N)	Pecans	1	Vetch
1	Dates	1	Peppers	0.1(1)(N)	Walnuts
1	Dewberries	1	Pineapples	1	Wheat
1	Egg plants	1	Plums (fresh prunes)	1	Youngberries

Administrative guidelines - none.
Tolerances pending - all interim tolerances above.
(1) - Interim tolerances.
(N) - Negligible residue tolerances.
[a] Tolerances apply to combined methyl parathion and parathion if both are present.
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International Tolerances - Tolerances established by individual nations may be based on recommendations of the FAO/WHO Expert Committee on Food Additives. The Committee evaluates all residue data submitted by interested parties and uses the following criteria (FAO/WHO, 1962,[1]) for making tolerance recommendations:

1. Decide upon the effective level of the food additive under consideration that would be needed in good technological practice.

2. Examine the possible uses and list all the foods in which the food additive might be used.

3. Calculate the daily intake level that might occur if the food additive was used in all the foods for which it might be a useful additive, working on the basis of the average intake of the food materials containing the additive. This average intake for appropriate population groups is obtained from national food consumption surveys.

4. Obtain the necessary information from which to calculate the average body weight of the population group concerned (usually between 50 to 70 kg).

5. From this information, calculate the intake of the additive in milligrams per kilograms of body weight per day.

6. Check the figure against the acceptable intakes given for the substances in the table. If it falls within the unconditional intake zone, the situation is satisfactory and the level proposed may be accepted. If it falls within the conditional intake zone, further scientific advice is required before the level of use proposed is accepted.

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[1] FAO/WHO, Food and Agricultural Organization of the United Nations/ World Health Organization, "Evaluation of the Toxicity of a Number of Antimicrobials and Antioxidants," Sixth Report, Joint FAO/WHO Expert Committee on Food Additives, World Health Organization Tech. Rept. Series No. 228, Geneva (1962).

The validity of the above criteria was reaffirmed at the 1966 FAO/WHO meeting (FAO/WHO, 1967[1]).

The recommendations for methyl parathion tolerances established by the 1968 Joint Meeting of the FAO and WHO (FAO/WHO, 1969) are:

Vegetables	1 ppm
Cole crops, cucurbits, fruit	0.2 ppm
Cottonseed oil (as processed)	0.005 ppm

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[1] FAO/WHO, Food and Agricultural Organization of the United Nations/World Health Organization, "Specifications for the Identity and Purity of Food Additives and Their Toxicological Evaluation: Some Emulsifiers and Stabilizers and Certain Other Substances," 10th Report, Joint FAO/WHO Expert Committee on Food Additives, World Health Organization Tech. Rept. Series No. 373, Geneva (1967).

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SUBPART II. B. PHARMACOLOGY AND TOXICOLOGY

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In the following section, information is given on the acute, subacute, and chronic toxicity of methyl parathion in laboratory animals. The symptomatology and pathology associated with mammals is discussed, and the physiological and pharmacological aspects of exposure to methyl parathion have been summarized. Methyl parathion is also reviewed with regard to its absorption, distribution, excretion, biotransformation, and residues in tissues. Information has been sought on the toxicity of this organophosphate compound in terms of its impact on reproduction, anomalies in the young, and behavioral, mutagenic and oncogenic effects. The effects of methyl parathion on humans has been reviewed relative to its acute, subacute and dermal toxicity, inhalation effects, symptoms, possible occupational hazards and accidental exposure hazards. The section summarizes rather than interprets scientific data reviewed.

Acute, Subacute and Chronic Toxicity

Toxicity to Laboratory Animals -

Acute oral toxicity - rats - The oral LD_{50} values calculated from the results of several studies are shown in Table 5. On the average there appears to be relatively little difference between the oral LD_{50} values for males (LD_{50} 11.07 mg/kg; range 6.0 to 16.0 mg/kg) and for females (LD_{50} 15.95 mg/kg; range 4.5 to 24 mg/kg). It appears that weanling rats (LD_{50} 8.1 mg/kg are more susceptible than mature animals.

Acute toxicity - rats, routes other than oral - Data are presented in Table 6 for the toxicity of methyl parathion by intraperitoneal, dermal and inhalation rates. With the few values that were found that order of sensitivity is: inhalation (LC_{50} 1 hr - 0.2 mg/liter; LC_{50} 4 hr - 0.12 mg/liter); intraperitoneal (LD_{50} 3.55 mg/kg); and dermal exposure (LD_{50} 67 mg/kg).

Subacute and chronic oral toxicity - rats - Data on the subacute and chronic oral toxicity in rats were not found in the literature.

Acute oral toxicity - mice - The acute oral toxicity information that was found for methyl parathion in mice is shown in Table 7. Most of the information has been published in recent years. The average LD_{50} values for male-female groups of mice is 18.5 mg/kg. Most of the LD_{50} values are grouped around 17 mg/kg.

Table 5. ACUTE ORAL TOXICITY - RATS

Measurement (mg/kg* unless otherwise noted)	Male	Female	Male female	Weanling male	Reference
Oral LD_{50}	9.7	4.5	--	--	a/
Oral LD_{50}	12-16	--	--	--	b/
Oral LD_{50}	14	24	--	--	c,d/
Oral LD_{50}	--	--	24.5	--	e/
Oral LD_{50}	--	7.0	--	--	f/
Oral LD_{50}	5.8	--	--	3.5	g,h/
Oral LD_{50}	--	9.7-14.8	--	--	i/
Oral LD_{50}	6.0	--	--	--	j/
Oral LD_{50}	14.0	24.0	--	--	k/
Oral LD_{50}	--	--	17.2	--	l/
Oral LD_{50}	--	--	14.0	--	m/
Oral LD_{50}	14.0	24.0	--	--	n/
Oral LD_{50}	--	--	--	12.7	o/
$\bar{X}$ LD_{50}	11.07	15.95	18.6	8.1	--

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* Body weight.

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m/ Servintuna, C., "The Acute Toxicity of Insecticides at Oral and Dermal Application," Bitki Koruma Bulteni, 3(4):275-284 (1963).

n/ Hayes, W. J., Jr., Clinical Handbook on Economic Poisons: Emergency Information for Treating Poisoning, U.S. Department of Health, Education, and Welfare Service, Communicable Disease Center, Atlanta, Georgia, p. 13 (1963).

o/ DuBois, K. P., M. Mazur, and K. W. Cornman, "Toxicity and Anticholinesterase Action of p-Nitrophenyl Dimethyl Thionophosphate," Fed. Proc., 9:269 (1950).

Table 6. ACUTE TOXICITY RATS - ROUTES OTHER THAN ORAL

Measurement (mg/kg* unless otherwise noted)	Male	Female	Male female	Reference
IP - LD_{50}	--	--	3.5	a/
IP - LD_{50}	--	--	3.6	b/
D - LD_{50}	67	--	--	c/
D - LD_{50}	67	67	--	d,e/
D - LD_{50}	--	--	67	f/
D - LD_{50}	67	67	--	g/
IN - LC_{50} (mg/ℓ) 1 hr	0.2	--	--	h/
IN - LC_{50} (mg/ℓ) 4 hr	0.12	--	--	h/

IP = Intraperitoneal.
D = Dermal.
IN = Inhalation.

* Body weight.

a/ DuBois, K. P., and J. M. Coon, "Toxicology of Organic Phosphorus-Containing Insecticides to Mammals," AMA Arch. Ind. Hyg. Occup. Med., 6:9-13 (1952).

b/ DuBois et al., op. cit. (1950).

c/ Edson et al., op. cit. (1965).

d/ Gaines, op. cit. (1969).

e/ Gaines, op. cit. (1960).

f/ Servintuna, op. cit. (1963).

g/ Hayes, op. cit. (1963).

h/ Kimmerle and Lorke, op. cit. (1968).

Table 7. ACUTE ORAL TOXICITY - MICE

Acute Oral LD_{50} (mg/kg body weight)			
Male	Female	Male female	Reference
--	--	17.1	a/
--	--	150.0	b/
--	--	18.5	a/
--	--	32.1	c/
--	--	17.0	d/
--	--	17.0	e/
--	--	9.3	f/
		18.5 g/ Average	

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a/ Rosival, L., F. V. Selecky, and L. Vbrovsky, "Acute Experimental Poisoning With Organophosphorus Insecticides," *Bratislav. Lekarske Listy*, 38:151-160 (1958).

b/ Wills, *op. cit.* (1969).

c/ Ikeda, Y., "Report to the Japan Academy of Sciences," (1962), quoted in "1968 Evaluations of Some Pesticide Residues in Food," *The Monographs*, Food and Agriculture Organization of the United Nations and the World Health Organization, Geneva (1969).

d/ Suzuki, S., "Fenitrothion (Sumithion)," *Noyaku Seisan Gijutsu*, 22: 57-69 (1970).

e/ Miyamoto, *op. cit.* (1969).

f/ DuBois, *op. cit.* (1971).

g/ Does not include the value reported by Wills (1969).

Acute toxicity - mice, routes other than oral - There was little difference between the average LD_{50} values by the intravenous (average LD_{50} 9.8 mg/kg), intraperitoneal (average LD_{50} 12.4 mg/kg), and subcutaneous routes (LD_{50} 18.0 mg/kg) reported as shown in Table 8 . All the above values were for male-female groups. There appears to be very little difference in toxicity of methyl parathion for mice with regard to the route of administration.

Subacute and chronic oral toxicity - mice - No information was available on either the subacute or chronic oral toxicities of methyl parathion to mice from the available literature.

Acute oral toxicity - guinea pigs - The acute oral toxicity of methyl parathion to the guinea pig has been reported to be 417 mg/kg body weight (Miyamoto, 1969). This value is the highest level of methyl parathion toxicity that was found for any mammalian species.

Acute toxicity - guinea pigs, routes other than oral - Miyamoto (1969) reports an intravenous LD_{50} of 50 mg/kg of methyl parathion for the guinea pig.

Subacute and chronic oral toxicity - guinea pigs - No information was found concerning the subacute or chronic oral toxicity of methyl parathion to guinea pigs.

Acute, subacute and chronic toxicity - dogs - An unreferenced short-term study has been reported (Anon., FAO/WHO, 1969[1/]) for the exposure of dogs to methyl parathion. The feeding study was carried out for 12 weeks. In early test groups there were two dogs, and four dogs were used for controls. The dieting levels were 5, 20, and 50 ppm. The only information that was given was relative to RBC and plasma cholinesterase activity. In the higher doses (20 and 50 ppm) the RBC cholinesterase was depressed significantly, soon after the commencement of the test diet. The maximum depression occurred at the 12th week. The animal recovered within 4 to 8 weeks after withdrawal of the insecticide. There was a significant depression of the plasma cholinesterase activity for the animals at the 50-ppm methyl parathion level. There were no significant depression of plasma cholinesterase activity at the 5-ppm level and depression was questionable at the 20-ppm level.

Acute, subacute and chronic toxicity - cats - No toxicity information for cats for methyl parathion was found in the literature.

[1/] Anon., Food and Agriculture Organization of the United Nations and the World Health Organization, "1968 Evaluations of Some Pesticide Residues in Food," The Monographs, Geneva (1969).

Table 8. TOXICITY OF METHYL PARATHION - MICE, BY ROUTES OTHER THAN ORAL

	LD_{50} (mg/kg)			
Route	**Male**	**Female**	**Male female**	**Reference**
IV	--	--	14.2	a/
	--	--	2.3	a/
	--	--	13.0	b/
			9.8 Average	
IP	--	--	18.5	a/
	--	--	8.6	a/
	11.0	--	--	c/
	--	--	10.0	d/
			12.4 Average	
SC	--	--	18.0	a/

IV = Intravenous injection.
IP = Intraperitoneal injection.
SC = Subcutaneous injection.

a/ Rosival et al., op. cit. (1958).

b/ Miyamoto, op. cit. (1969).

c/ Benke, G. M., K. L. Cheever, F. E. Mirer, and S. D. Murphy, "Comparative Toxicity Anticholinesterase Action and Metabolism of Methyl Parathion in Sunfish and Mice," *Toxicol. Appl. Pharmacol.*, 28:97-109 (1974).

d/ Dorough, H. W., "Effect of Temik® on Methyl Parathion Toxicity to Mice," Progress Report, Texas A&M University No. 2771:1-6 (May 1970).

Acute, subacute and chronic toxicity - rabbits - Wills (1969) has reported that the oral LD_{50} value in rabbits is 420 mg/kg; the dosage was given in oil. In the undiluted form the LD_{50} value was 1,270 mg/kg.

Toxicity to Other Domestic Animals - No references to the toxicity of methyl parathion to other domestic animals were found in the literature.

Symptomatology and Pathology Associated with Mammals - Because relatively few studies have been conducted with methyl parathion, there are few descriptions of symptoms which follow ingestion, absorption, or inhalation of an acute dose.

Generally, the symptoms may be described as those characteristic of poisonings with materials belonging to the organic-phosphorus class of insecticides: restlessness, muscular twitchings, miosis, defecation, urination, lacrimation, incoordination, prostration, generalized muscular fibrillation, convulsions and death.

In the rabbit, methyl parathion does not appear to produce any consistent gross pathological changes, and the signs of poisoning take longer to appear in the rabbit than in guinea pigs and rats. Symptoms take longer to appear in the guinea pig than in the rat (Deichmann et al., 1952).

Observation of dogs poisoned with methyl parathion suggest that after receiving an acute dose the sequence of events in the dog may be as follows: moderate tremors and salivation, followed by pronounced tremor, nausea, and dyspnea, and followed by very pronounced tremor, convulsions, prostration, vomiting, unconsciousness, and eventually death (Vandekar et al., 1965[1/]).

Physiological and Pharmacological Aspects of Methyl Parathion - Methyl parathion and parathion are biologically similar and they both metabolize to oxygen analogs--paraoxon and methyl paraoxon (Augustinsson and Jonsson, 1957[2/]). Methyl parathion is a cholinesterase inhibitor

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[1/] Vandekar, M., B. Svetlicic, and T. Fajdetic, "The ED_{50} Value as Opposed to LD_{50} Value in Acute Toxicity of Some Anticholinesterases," WHO/Vector Control/163.65 (1965).

[2/] Augustinsson, K. B., and G. Jonsson, Acta Chem. Scand., 11:375 (1957), quoted in "1968 Evaluations of Some Pesticide Residues in Food," The Monographs, Food and Agriculture Organization of the United Nations and the World Health Organization, Geneva (1969).

(Williams et al., 1959[1]) and is weaker in this capacity than parathion (DuBois and Coon, 1952). Also, the analog methyl paraoxon is weaker than ethyl paraoxon (Davidson, 1955[2]).

Ethyl and methyl parathion are similar in their physiological and pharmacological activity of cholinesterase inhibition. The following general discussion on the mechanism of action of acetylcholinesterase inhibitions is based on Hamblin and Golz (1955).[3]

Acetylcholine, a neurotransmiter, is needed for impulse transmission and this need is met by the action of the enzyme choline acetylase. The hydrolysis of acetylcholine to choline and acetic acid is accomplished by another enzyme, acetylcholinesterase (AChE). There are a number of cholinesterases, the more prominent being true and pseudocholinesterase. The former is found in nerve and muscle tissue and in the erythrocytes. Pseudocholinesterase is found in the pancreas and salivary glands and other tissues. The letter enzyme hydrolyzes acetylcholine slowly.

The plasma cholinesterase is usually a mixture of true and pseudo forms. The concentration varies widely from individual to individual, and plasma contains mostly pseudocholinesterase.

The absorption of parathion, an inhibitor of pseudocholinesterase brings about the accumulation of sympathetic postganglionic fibers, in sympathetic ganglia, and in the central nervous system, as well as at the myoneural junctions of muscle.

The only cumulative aspect of parathion that is suggested is that the inhibition is not reversible and acetylcholine recovery period is contingent upon the death of the red cell. Repeated doses of parathion will produce steadily decreasing levels of enzyme activity.

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[1] Williams, M. W., H. N. Fuyat, and O. G. Fitzhugh, "The Subacute Toxicity of Four Organic Phosphates to Dogs," Toxicol. Appl. Pharmacol., 1:1-7 (1959).

[2] Davidson, A. N., "Return to Cholinesterase Activity in the Rat After Inhibition of Organophosphorus Compounds. II. A Compositive Study of True and Pseudo Cholinesterase," Biochem. J., 60:339-346 (1955).

[3] Hamblin, D. O., and H. H. Golz, "Parathion Poisoning, A Brief Review," Ind. Med. Surg., 24(22):65-72 (1955).

In the diagnosis of parathion poisoning, the RBC cholinesterase level is the more important clinical measurement. The excretion of p-nitrophenol is indicative of p exposure. Plasma cholinesterase is more nonspecific and it has no functional relationship with the activity of the nervous system. A presumptive diagnosis of poisoning is assumed when the plasma and RBC cholinesterase activity is depressed by 25%.

In acute poisoning, manifestations usually occur only after more than 50% of the plasma cholinesterase is inhibited. After an acute poisoning it takes about 4 weeks for plasma cholinesterase and about 5 weeks for RBC cholinesterase to return to normal.

Summary of Acute, Subacute and Chronic Toxicity - Methyl parathion is a highly poisonous insecticide. Its principal physiological action is to inhibit the cholinesterases. The acute oral toxicity in mammals is summarized in the following table;

Table 9. ACUTE ORAL TOXICITY OF METHYL PARATHION IN MAMMALS (LD_{50} Values)

	Male (mg/kg)	Female (mg/kg)	Male and female
Rats	11.07 (7)[a]	15.95 (6)[a]	--
Mice	9.7	4.5	18.5 (7)[a]
Guinea pigs	--	--	417[b]
Rabbits	---	--	1,270[c] 420[d]

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[a] Average values ( ) number.
[b] Sex was not stated.
[c] Not carried in a solvent; sex was not given.
[d] Given in oil; sex was not given.

It is rather striking that the LD_{50} values for guinea pigs and rabbits are high compared to rats and mice. The toxicity of methyl parathion by other routes of administration, other than oral, for mammals is shown in Table 10.

Table 10. ACUTE TOXICITY OF METHYL PARATHION TO MAMMALS BY ROUTES OTHER THAN ORAL (LD_{50} and LC_{50} Values)

	Intra-venous (mg/kg)	Intra-peritoneal (mg/kg)	Sub-cutaneous (mg/kg)	Dermal (mg/kg)	Inhala-tion (mg/ℓ)
Rats	--	3.5	--	67	0.2[a]
Mice	9.8	12.4	18.0	--	0.12[b]
Guinea pigs	50.0	--	--	--	--

a/ One-hour exposure.
b/ Four-hour exposure.

No subacute or chronic toxicity information was found for rats, mice, guinea pigs, cats or rabbits. There was one paper that described a 12-week feeding study with methyl parathion in dogs. It was reported that the RBC cholinesterase was significantly depressed at 20 and 50 ppm. The plasma cholinesterase was significantly depressed at 50 ppm.

No information was found on the toxicity of methyl parathion in domestic animals.

The symptoms of methyl parathion poisoning in mammals are quite similar to other organic-phosphorus compounds. The progression includes restlessness, tremors, miosis, loss of coordination, nausea, vomiting, muscle fibrillation, convulsions and death..

The physiological and pharmacological aspects of methyl parathion toxicity center around the inhibitory effect on cholinesterases.

Metabolism of Methyl Parathion

Adsorption - A report by Nemec et al. (1968[1]) stated that two entomologists entered a field that had been sprayed 2 hr earlier with 2 lb/acre of methyl parathion. They apparently adsorbed 2 to 10 mg of methyl parathion and had a 40% inhibition of red cell acetylcholinesterase.

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[1] Nemec, S. J., P. L. Adkisson, and H. W. Dorough, "Methyl Parathion Adsorbed on the Skin and Blood Cholinesterase Levels of Persons Checking Cotton Treated With Ultra-Low-Volume Sprays," J. Econ. Entomol., 61(6):1740-1742 (1968).

Fujinami (1963)[1] demonstrated absorption and cholinesterase inhibition in rats, mice and guinea pigs treated with methyl parathion and methyl paraoxon.

Distribution - Miyamoto (1964)[2] studied the distribution of methyl parathion after intravenous administration to rats and guinea pigs. Lung and liver were found to be richest in methyl paraoxon. Orally administered methyl parathion inhibited brain and blood cholinesterase in rats, mice and guinea pigs within 1 hr (Fujinami, 1963).

Mice treated with 17 mg/kg of radioactive (^{32}P) methyl parathion excreted the following compounds within 24 hr after dosage: dimethyl phosphoric acid, 31.9% (percent of radioactivity in the urine); methyl phosphate, 23.1%; methyl phosphorothioate, 18.8%; dimethyl phosphorothioic acid, 12.9%; phosphoric acid, 5.8%; unknown products, 3.1%; phosphate, 2.4%; and methyl phosphoric acid, 2.0% (Hollingworth et al., 1967[3]).

Biotransformation -

Activation - Metcalf and March (1953)[4] demonstrated that pure methyl parathion did not inhibit fly brain acetylcholinesterase unless it was converted to the oxygen analog by other tissues. Aldridge (1954)[5] reported that methyl parathion inhibited several esterases besides acetylcholinesterase. Inhibition required conversion to the oxygen analog. The inhibition and reversal rate varied widely with different enzymes in the same species of animal.

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[1] Fujinami, A., "Studies on the Mode of Action of Organophosphorus Compounds. Part II. Inhibition of Mammalian Cholinesterase *in vivo* Following the Administration of Sumithion and Methyl Parathion," *Agr. Biol. Chem.*, 27(1):669-676 (1963).

[2] Miyamoto, J., "Studies on the Mode of Action of Organophosphorus Compounds. Part III. Activation and Degradation of Sumithion and Methyl Parathion in Mammals *in vivo*," *Agr. Biol. Chem.*, 28(7):411-421 (1964).

[3] Hollingworth, R. M., R. L. Metcalf, and T. R. Fukuto, "The Selectivity of Sumithion Compared With Methyl Parathion. Metabolism in the White Mouse," *J. Agr. Food Chem.*, 15(2):242-249 (1967).

[4] Metcalf, R. L., and R. B. March, "Further Studies on the Mode of Action of Organic Thionophosphate Insecticides," *Ann. Entomol. Soc. Am.*, 46:63-74 (1953).

[5] Aldridge, W. N., "Anticholinesterases," *Chemistry and Industry*, pp. 473-476 (1954).

Dahm et al. (1962)[1] compared the activation of methyl parathion by rat liver microsomal preparations in the presence of NADH$_2$, magnesium ion and nicotinamide. Activation of methyl parathion could be prevented by pretreatment with piperonyl butoxide, sulfoxide, sesamex, testosterone propionate, androstanolone, estradiol, estrone and SKF-525A. Brindley and Dahm (1964)[2] reported that rat liver microsomes, NADH$_2$ and borate buffer at pH 7.7 at room temperature converted methyl parthion to methyl paraoxon. Vardanis and Crawford (1964)[3] found that the supernatant fraction of mouse liver converted methyl parathion to methyl paraoxon. Johnsen and Dahm (1966)[4] studied the activation of methyl parathion by liver microsomes from eight species. The results of their studies are summarized as follows:

	Liver microsomal protein nitrogen (µg/100 mg)		Methyl parathion activation (-log I_{50})	
Species	Male	Female	Male	Female
Cattle	425	311	6.89	6.10
Chickens	223	333	5.34	6.17
Ducks	212	321	6.68	7.07
Guinea pigs	211	266	5.52	5.20
Hogs	290	266	5.36	5.66
Mice	288	353	6.64	6.77
Rats	284	225	7.01	5.68
Sheep	349	343	5.73	4.50

1/ Dahm, P. A., B. E. Kopecky, and C. B. Walker, "Activation of Organophosphorus Insecticides by Rat Liver Microsomes," Toxicol. Appl. Pharmacol., 4:683-696 (1962).

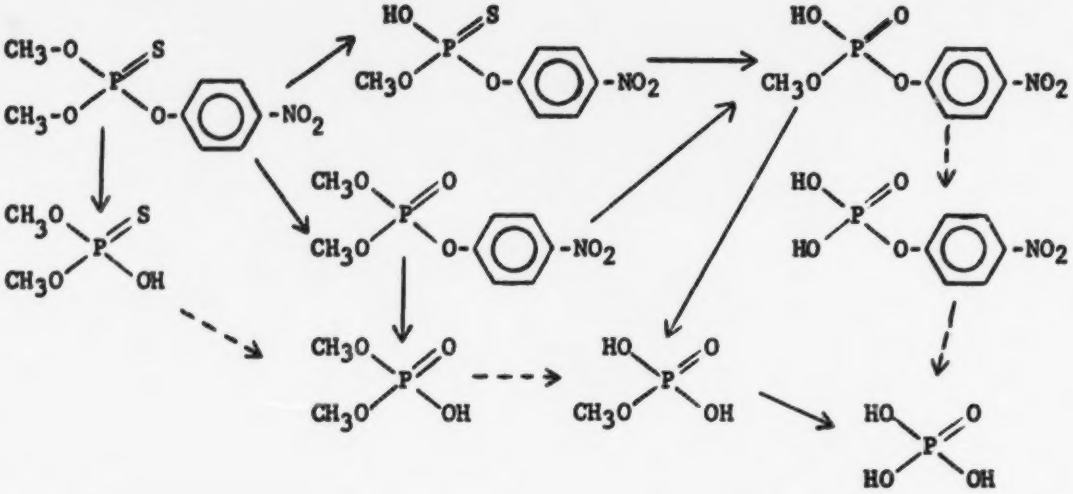
2/ Brindley, W. A., and P. A. Dahm, "Identification of the *in vitro* Anticholinesterase Metabolite of Methyl Parathion," J. Econ. Entomol., 57:47-49 (1964).

3/ Vardanis, A., and L. G. Crawford, "Comparative Metabolism of O,O-Dimethyl O-*p*-nitrophenyl Phosphorothioate (Methyl Parathion) and O,O-Dimethyl O-(3-Methyl-4-Nitrophenyl) Phosphorothioate (Sumithion)," J. Econ. Entomol., 57:136-139 (1964).

4/ Johnsen, R. E., and P. A. Dahm, "Activation and Degradation Efficiencies of Liver Microsomes From Eight Vertebrate Species, Using Organophosphates as Substrates," J. Econ. Entomol., 59(4):1437-1442 (1966).

Cheymol and Goyer (1966)[1] found the sulfur analog much less toxic to true and pseudocholinesterase.

Degradation (detoxification) - Miyamoto (1964) reported that intravenous methyl parathion in rats and guinea pigs was detoxified to desmethyl compounds and dimethylphosphorothioic acid in the liver and kidney. Mendoza and Hatina (1970)[2] extracted liver esterases from male rhesus monkeys, chickens, turkeys, steers, barrows and sheep. Steer esterases were slighly inhibited by methyl parathion but sheep esterases were not inhibited. All others were strongly inhibited by methyl parathion. Hollingworth et al. (1967) offered the following pathways for the metabolism of methyl parathion. The broken arrows indicate hypothetical pathways.



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[1] Cheymol, J., and R. Goyer, "Contribution à l'Étude Pharmacologique de Quelques Dérivés Soufrés de l'Acide Orthophosphorique Trisubstitué. I. Détermination du Pouvoir Anticholinésterasique *in vitro*," Rev. Can. Biol., 25(1):41-48 (1966).

[2] Mendoza, C. E., and G. V. Hatina, "Starch-Gel Electrophoresis of Liver Esterases Selectively Inhibited by Pesticides," Bull. Environ. Contam. Toxicol., 5(2):181-190 (1970).

Johnsen and Dahm (1966) also studied the degradation of methyl paraoxon by liver microsomes from eight animal species. Results of their studies are summarized as follows:

Species	Activation (-log I_{50}) Male	Activation (-log I_{50}) Female
Cattle	7.44	7.43
Chickens	7.36	7.36
Ducks	7.33	7.22
Guinea pigs	6.96	6.91
Hogs	7.32	7.16
Mice	7.15	7.10
Rats	7.14	7.37
Sheep	7.23	6.62

Miyamoto et al. (1968)[1/] studied the metabolism of methyl parathion by microsomes from rat, mouse and guinea pig liver. All required $NADH_2$ or $NADPH_2$ to convert methyl parathion to methyl paraoxon. Oxygen analogs were more rapidly metabolized than the phosphorothioates. Mouse liver was most efficient in demethylation reactions. Glutathione was essential as a methyl acceptor or as an activator. Benke et al. (1974) found the demethylation of methyl parathion was via a glutathione-dependent liver enzyme. Fukunaga et al. (1969)[2/] found that the metabolism of methyl parathion by rat liver microsomes reqired reduced glutathione and liver soluble fraction. The conversion of methyl parathion directly to desmethyl parathion was the principal pathway in the presence of glutathione. Rao and McKinley (1969)[3/] studied the metabolism of methyl parathion by liver homogenates from chickens, rats, guinea pigs and rhesus monkeys. The demethylation reaction was more active than the oxidative pathways.

[1/] Miyamoto, J., Y. Sato, K. Yamamoto, and S. Suzuki, "Activation and Degradation of Sumithion, Methyl Parathion and Their Oxygen Analogs by Mammalian Enzymes in vitro," Botyu-Kagaku, 33:1-7 (1968).

[2/] Fukunaga, K., J. Fukami, and T. Shishido, "The in vitro Metabolism of Organophosphorus Insecticides by Tissue Homogenates from Mammal and Insect," Residue Rev., 25:223-249 (1969).

[3/] Rao, S. L. N., and W. P. McKinley, "Metabolism of Organophosphorus Insecticides by Liver Homogenates From Different Species," Can. J. Biochem., 47:1155-1159 (1969).

Tissue Residues - The binding of methyl parathion to the esterase enzymes in an irreversible manner is the only tissue accumulation that has been studied.

Summary -

1. Methyl parathion and its oxygen analog are readily absorbed through the skin and from the stomach.

2. The distribution of injected methyl parathion is associated with several tissues but is most concentrated in liver and lung.

3. Excretion products of methyl parathion are mainly dimethyl phosphoric acid, methyl phosphate, methyl phosphorothioate, dimethylphosphorothioic acid and phosphoic acid.

4. Methyl parathion is converted to its toxic oxygen analog by liver microsomes.

4. Demethylation is the principal *in vitro* detoxifying pathway of methyl parathion in the presence of reduced gluththione.

Effects on Reproduction

Rats - An unpublished report by the Woodard Research Corporation was reviewed by Anon., FAO/WHO (1969). This report was concerned with a three-generation study in rats. The dose level was 0, 10 and 30 ppm. In a two-litter-per-generation study there was no consistent effect on the number of live or stillbirths, physical structure of newborn, litter size, weanling weights or percentage survival to weaning. The only consistent effect was reduced productive performance in the F1a, F1b, F2a and F3b generation at 30 ppm. Sporadic effects included lower weanling survival rate in F1a, F1b, and F2a generations at 30 ppm, and in F3a generation at 10 ppm; increased stillbirth rate in F1b and F3a generations at 30 ppm and F3a at 10 ppm; reduced mean weanling rate in F2a generation at 30 ppm and F1b generation at 10 ppm. There was no reduced reproductive performance activity noted at the 10-ppm level, which approximates 0.5 mg/kg/day.

Avian Species - Shellenberger et al. (1968)[1] found that egg production of Japanese quail was inhibited. Hatchability was reduced by 60 ppm of methyl parathion. This was in contrast to parathion where hatchability was reduced by 27 ppm.

Teratogenic Effects

Mammals - Fish (1966)[2] reported on a teratology study with rats. Dosage levels were 4 and 6 mg/kg. He obtained negative results on a single dose in methyl parathion groups tested on days 9 and 15 of gestation. Only one embryo in the methyl parathion group developed an axillary hematoma. Methyl parathion was administered (4 mg/kg) to additional animals on the 9th and 15th day of gestation and these animals were allowed to deliver. There were no stillbirths or gross anomalies of the young for the animal injected on the 9th day of gestation. The litter from the mother injected on the 15th day of gestation resulted in one stillbirth and no gross anomalies.

Tanimura et al. (1967)[3] studied the teratogenic effects in rats and mice that were injected intraperitoneally on day 12 of gestation in the rats and on day 10 in the mice. The dosage was 5, 10 and 15 mg/kg body weight in the rats and 20 and 60 mg/kg in the mice. The highest dose in both species was near the LD_{50}. All the animals of both species exhibited signs of toxicity 30 min after administration of the compound regardless of the dosage level. The observations on the fetuses in rats and mice are shown in Tables 11 and 12. He found no significant external or internal malfunctions in rats, whereas the mice showed more embryotoxicity.

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[1] Shellenberger, T. E., J. B. Gough, and L. A. Escuriex, "Comparative Toxicity Evaluation of Organophosphate Pesticides With Wildlife," Ind. Med. Surg., 37:537 (1968).

[2] Fish, S. A., "Organophosphorus Cholinesterase Inhibition and Fetal Development," Amer. J. Obstet. Gynecol., 96(8):1148-1154 (1966).

[3] Tanimura, T., T. Katsuya, and H. Nishimura, "Embryotoxicity of Acute Exposure to Methyl Parathion in Rats and Mice," Arch. Environ. Health, 15:609-613 (November 1967).

Table 11. EFFECT ON OFFSPRING OF A SINGLE INTRAPERITONEAL INJECTION OF METHYL PARATHION IN PREGNANT RATS ON DAY 12

Dosage (mg/kg)	No. of litters (dead)	Offspring			Skeletal variations			
		Total no. (litter size)	Dead (%)	Mean body weight (g)	No. of fetuses examined	Cervical rib	Rib No. 14	Asymmetry of sternebrae
15	13 (3)	109	12	4.30	34	0	2	3
10	10	115	11	4.86	34	1	0	1
5	10	115	8	4.73	34	0	1	4
0[a]	10	111	10	4.78	30	0	0	2

Data from Tanimura et al., *op. cit.* (1967).

[a] Sodium carboxymethyl cellulose.

Table 12. EFFECT ON OFFSPRING OF A SINGLE INTRAPERITONEAL INJECTION OF METHYL PARATHION IN PREGNANT MICE ON DAY 10

		Offspring				Skeletal variations						
											State of ossification	
Dosage (mg/kg)	No. of litters (dead)	Total no.	Dead	Malformations[b]	Mean body weight (g)	No. of fetuses examined	Bifurcated C-1 or C-2	Cervical rib	Rib No. 14	Asymmetry of sternebrae	Nonfused supra-occipital	Under-developed sternebrae
60	14 (5)	112	25	13	1.16	30	5	8	1	2	2	0
20	11	143	6	2	1.26	37	3	8	1	3	0	5
0[a]	8	102	2	0	1.25	30	3	1	1	0	1	1

Data from Tanimura et al., op. cit. (1967).

[a] Sodium carboxymethyl cellulose.

[b] Cleft palate.

Lethality, teratogenicity, and suppression of growth was noted in the group treated with the higher dosage. The major malformation in the mouse, at high dosage, was cleft palate. The cleared specimens of the rat did not indicate any skeletal malformations had taken place (Table 11). In the mice nonfused supraoccipital occured at the 60 mg/kg dosage. At the dosage of 20 mg/kg some incidence of underdeveloped sternebrae occured. The investigators did not find these malformations significant at the 5% level. However, in the 1968 FAO/WHO Report (Anon., FAO/WHO, 1969) the statement was made, "It was therefore found necessary to reevaluate this compound by using a higher safety factor which changes the acceptable daily intake to a temporary acceptable daily intake." The estimate of temporary acceptable intake was set at 0 to 0.001 mg/kg/body weight. The adjustments were predicated on the observed teratogenic effects in mice after parenteral administration, and on the reproductive studies in rats that showed some disturbances of the physiology of the reproductive process.

Behavioral Effects

No information was found in the literature on the behavioral effects of methyl parathion.

Toxicity Studies With Tissue Culture

Huang (1973)[1/] investigated the effect on cell growth after treatment with three organophosphates: disulfoton, malathion and methyl parathion. The evaluation was made with human hematopoietic cell lines that were derived from blood of normal male individuals. The concentrations of methyl parathion were 25, 20, 75, and 100 ug/ml. Growth was reduced at all concentrations generally in proportion to the concentration given. At 50 hr the media containing the pesticide was removed and fresh media free of pesticide was added. A rapid normal growth resumed except for the cells previously treated with 100 ug/ml of methyl parathion. These cells died within the first day.

[1/] Huang, C. C., "Effect on Growth but not on Chromosomes of the Mammalian Cells After Treatment with Three Organophosphorus Insecticides," Proc. Soc. Exp. Biol. Med., 142(1):36-40 (1973).

Mutagenic Effects

Only one report was found that yielded information on mutagenic studies in regard to methyl parathion (Huang, 1973). In this study the effect of methyl parathion on chromosomes of cells in vivo was studied using ICR male mice which had been injected intraperitoneally with 5, 10, 20, 50 or 100 mg of the compounds per kilogram of body weight. The mice that were injected with the higher doses of methyl parathion (50 and 100 mg/kg) died within 1 hr after injection. All the mice lived at the lower concentration for 24 hr after injection. Bone marrow tissue for chromosome study was taken from the femurs. Methyl parathion caused no increase in the incidence of chromosome aberrations in cells. The authors suggested that the animals that died at the higher dosage level very likely died due to nervous system toxicity.

Oncogenic Effects

No information was found in the literature on long-term studies relative to the oncogenic effects of methyl parathion.

Effect on Humans

Acute and Subacute Toxicity - No information was found for the lethal dose of methyl parathion for man.

Through the 1960's Rider and his co-workers (1963, 1964, 1967, 1969a, 1969b)[1-5] at the Franklin Hospital Foundation in San Francisco,

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[1] Rider, J. A., and H. C. Moeller, "Tolerance of Organic Phosphates in Man," Progress Report of Franklin Hospital Foundation, San Francisco, California (1 October 1963).

[2] Rider, J. A., and H. C. Moeller, "Studies on the Anticholinesterase Effects of Systox and Methyl Parathion in Humans," Fed. Proc., 23(2):176 (1964).

[3] Rider, J. A., H. C. Moeller, and E. J. Puletti, "Continuing Studies on Anticholinesterase Effect of Methyl Parathion, Initial Studies With Guthion, and Dichlorvos in Humans," Fed. Proc., 26(2):427 (1967).

[4] Rider, J. A., H. C. Moeller, E. J. Puletti, and J. I. Swader, "Toxicity of Parathion, Systox, Octamethyl Pyrophosphoramide, and Methyl Parathion in Man," Toxicol. Appl. Pharmacol., 14(3):603-611 (1969a).

[5] Rider, J. A., and E. J. Puletti, "Studies on the Anticholinesterase Effects of Gardona, Methyl Parathion, and Guthion in Human Subjects," Fed. Proc., 28(2): 479 (1969b).

evaluated tolerances to insecticides in experimental tests conducted with volunteers from the California State Prison at San Quentin. During these years these investigators worked with parathion, methyl parathion, malathion, demeton, and azinphos methyl. They usually used five subjects and two controls, and the insecticides were administered daily in capsules for periods of approximately 30 days. Samples of blood were taken prior to the test and twice a week throughout the tests for cholinesterase evaluations. Their definition of incipient toxicity was that amount of organophosphate ingested daily which produced an unequivocable depression of the average cholinesterase levels of five subjects of between 20 to 25%. They administered methyl parathion in one test (Rider and Moeller, 1963) at a level of 1 mg daily and without significant depression of RBC cholinesterase. This dosage was increased in subsequent periods of 0.5 mg increments to a level of 10 mg/day and did not establish an incipient toxicity. In another evaluation (Rider et al., 1967), the methyl parathion dosage was increased in two sets of subjects to 13 and 13-1/2 mg/day without depression of plasma and RBC cholinesterase. Later Rider and Puletti (1969b) raised the daily intake to dosages of 17, 18, 19, and 20 mg for 4 weeks. There was still no significant change in plasma or RBC cholinesterase levels.

Symptoms of Methyl Parathion Poisoning - The description of symptoms for organophosphates are generally treated without designating any peculiarity of symptoms ascribed to any one individual chemical. The symptoms described for parathion poisoning by Sumerford et al. (1953),[1] Arterberry et al. (1961),[2] Hamblin and Golz (1955), Tsachalinas et al. (1971),[3] and Namba (1971)[4] are similar to methyl parathion.

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[1] Sumerford, W. T., W. J. Hayes, Jr., J. M. Johnston, K. Walker, and J. Spillane, "Cholinesterase Response and Symptomatology From Exposure to Organic Phosphorus Insecticides," AMA Arch. Ind. Hyg. Occup. Med., 7:383-398 (1953).

[2] Arterberry, J. D., W. F. Durham, J. W. Elliot, and H. R. Wolfe, "Exposure to Parathion," Arch. Environ. Health, 3:476-485 (1961).

[3] Tsachalinas, D., G. Logaras, and A. Paradelis, "Observations on 246 Cases of Acute Poisoning With Parathion in Greece," Eur. J. Toxicol., 4:46-49 (1971).

[4] Namba, T., "Cholinesterase Inhibition by Organophosphorus Compounds and Its Clinical Effects," Bulletin of the World Health Organization, 44:289-307 (1971).

Namba (1971) has classified other signs and symptoms observed in 77 patients who developed poisoning by the application of ethyl and methyl parathion. The more prominent symptoms were weakness, nausea or vomiting, excessive sweating, headache, excessive salivation and difficulty in walking. Namba points out that if the exposure to an organophosphate insecticide is sufficient enough to develop symptoms, they usually appear in less than 12 hr. Symptomatology that appears 24 hr after exposure cannot be attributed to these pesticides. A critical clinical observation is the occurrence of miosis, which is found in about 50% of the patients, and appears even in subjects with mild cases. Death is usually attributed to failure of the respiratory muscles and paralysis of the respiratory center. Cardiac involvement may occur but it is usually at the terminal stage. Man appears to be more sensitive to the organophosphate insecticides, showing signs of symptoms earlier than experimental animals particularly central nervous system manifestations. If an untreated organophosphorus-poisoned victim is alive after 24 hr, he will recover. The account by Kanagaratnam et al. (1960)[1] describes a parathion poisoning incident from contaminated barley in India. There were 53 persons involved and the clinical features were described in some detail, concerning collapse, fits, sweating, dyspnea, miosis, unstable blood pressure, coma, and muscular fasciculation.

Namba (1971) also presented an excellent description of the signs and symptoms of organophosphate poisoning in patients. Reference should be made to Hamblin and Golz (1955) for the onset and progressions of symptoms in subjects exposed to toxic amounts of parathion in spraying operations.

The pharmacology and toxicology of parathion poisoning have also been described by Hamblin and Golz (1955). These authors state that the only important pharmacological action of parathion is its action in the inhibition of enzyme acetylcholinesterase. This enzyme catalyzes the hydrolysis of acetylcholine. The absorption of parathion brings about the accumulation of acetylcholine, because of a failure in the disposal mechanism in parasympathetic postganglionic fibers, in sympathetic ganglia, and in the central nervous system, as well as at the myoneural junctions of muscle. In acute poisoning, manifestations usually occur only after more than 50% of the plasma cholinesterase is inhibited. After an acute poisoning it takes about 4 weeks for plasma cholinesterase to return to normal and about 5 weeks for RBC cholinesterase.

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[1] Kanagaratnam, K., W. H. Boon, and T. K. Hoh, "Parathion Poisons From Contaminated Barley," Lancet, 1:538-542 (1960).

Gershon and Shaw (1961)[1] followed the case histories of 16 persons suffering from psychiatric disorders, who had also been chronically exposed to organophosphorus pesticides for periods of time ranging from 1-1/2 to 10 years. Of the 16 cases studied, three were scientific workers, eight worked in greenhouses and five were farmworkers. Although all suffered some form of mental disorder, mental history prior to exposure to pesticides was not always known. Likewise severity of exposure and type of pesticides used were not always known. In general, schizophrenic and depressive reactions were observed with severe impairment of memory and difficulty in concentration. In a follow-up of four cases the symptoms persisted for 6 months after exposure ceased with reversion to normal in 12 months. As a result of a small field survey the authors suggest, "Psychiatric disorders might be commoner in fruit-growing areas than in towns."

No other surveys of this nature were found in the literature.

Fazekas (1971)[2] reported on the conditions at autopsy of 30 persons fatally poisoned by methyl parathion. Death had occurred in 2 to 9 days after oral ingestion. The subjects varied in age from 18 to 82 years. The principal changes noted were edema and hyperemia. Where death was prolonged, degenerative changes were observed. When death occurred unexpectedly, hemorrhages occurred in the myocardium and medulla oblongata. The hemorrhages were characterized as being multiple pericapillary and periprecapillary.

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[1] Gershon, S., and F. H. Shaw, "Psychiatric Sequelae of Chronic Exposure to Organophosphorus Insecticides," Lancet, pp. 1371-1374 (1961).

[2] Fazekas, I. G., "Macroscopic and Microscopic Changes in WOFATOX (Methyl Parathion) Intoxication," Z. Rechtsmed, 68:189-194 (1971).

Dermal Effects - No information was found in the literature on dermal toxicity of methyl parathion to humans.

Inhalation Effects - There was no data found concerning the inhalation toxicity of methyl parathion in humans.

Occupational and Accidental Exposure Hazards - In a broad sense occupational exposure hazards can be defined as exposure in field operations and in manufacturing plants.

Field operations - There have been a few reports on the potential exposure hazard to methyl parathion by workers in field operations. Quinby et al. (1958)[1] reported that the exposure while checking cotton from insect damage was 0.7 mg/hr dermal. The amount per hour taken in by the respiratory route was below the limits of the analytical method.

Nemec et al. (1968) studied the absorption of methyl parathion by persons checking cotton treated with ultralow volume (ULV) sprays. The study was made with two entomologists as subjects. The clothing worn by these observers was normal wear plus sleeveless laboratory uniforms. Their arms and hands were washed separately after they came from the treated fields.

The data in Table 13 indicates that the men absorbed substantial amounts of methyl parathion.

The RBC cholinesterase of the men was determined from 12 June through 13 August 1967. From 12 June to 4 August, the activity ranged between 90 and 95% of normal. On 30 August, the activity level for both men fell to 60% of normal. Previous to this date they had worked in the methyl parathion field on 16 August, 2 hr after spraying; 22 August, 24 hr after spraying, and 30 August, 2 hr after spray was applied.

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[1] Quinby, G. E., K. C. Walker, and W. F. Durham, "Public Health Hazards Involved in the Use of Organic Phosphorus Insecticides in Cotton Culture in the Delta Area of Mississippi," J. Econ. Entomol., 51: 831-838 (1958).

Table 13. **AMOUNTS OF METHYL PARATHION ABSORBED BY MEN WORKING IN ULV-TREATED FIELDS**

Exposure date	Time of exposure after treatment (hr)	Pounds of AI/acre	Methyl parathion (mg) Left arm	Right arm	Total
August	Entomologist 1 (180 lb)				
16	2	2	0.752	1.272	2.024
22	24	1.5	0.077	0.086	0.163
30	2	2	1.916	2.424	4.340
	Entomologist 2 (240 lb)				
16	2	2	1.666	2.710	4.340
22	24	1.5	0.153	0.198	0.351
30	2	2	3.883	6.029	10.092

Source: Nemec et al., op. cit. (1968).
Reprinted from J. Econ. Entomol., by permission of the Entomological Society of America.

These results indicate that the potential hazard is high when fields are entered 2 hr after spraying. Furthermore, treated fields should not be entered until 24 hr after treatment.

As has been reported by Ware et al. (1973)[1] the determination of safe reentry intervals is influenced by a number of factors including, (1) frequency and rate of application, (2) characteristics of the foliage, (3) height of the foliage, (4) density of the canopy, (5) the weather, and (6) inherent characteristics relative to the particular pesticide applied, i.e., persistance, toxicity, penetrability, etc. Other factors involved are the length of exposure time, the type of clothing worn, and the presence or absence of respiratory protection. The recommended reentry time established must be long enough to give protection to the worker but short enough to be tenable with profitable agricultural practice.

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[1] Ware, G. W., D. P. Morgan, B. J. Estesen, W. P. Cahill, and D. M. Whitacre, "Establishment of Reentry Intervals for Organophosphate-Treated Cotton Fields Based on Human Data: I. Ethyl and Methyl Parathion," Arch. Environ. Contam. Toxicol., 1(1):48-59 (1973).

In the study reported by Ware et al. (1973) concerning the aerial application of a mixture containing 0.5 lb of methyl parathion, 0.5 lb of ethyl parathion and 2.0 lb of toxaphene in 5 gal. of spray per acre, the crop was mature cotton, with bolls beginning to open. Ten minutes after application, two men entered the field and collected samples for 30 min; this operation was repeated at 12, 24, 48, and 72 hr after insecticide treatment.

Biomedical data indicated that there was no clinical evidence of plasma or RBC cholinesterase depression or of urinary p-nitrophenol in either subject (man) even when the field was entered immediately after treatment.

Ware et al. (1973) reported that from the accumulation of residues on skin and clothing an individual can expect exposure to the following amounts of mixed residues during a 30-min period at the times indicated after treatment of a cotton field with methyl parathion and parathion.

Time After Treatment (hr)	Hands and Forearms (mg)	Clothing (mg)	Inhalation (mg/ml)
0	3.47	18.21	1.06
12	1.93	12.11	0.60
24	1.16	6.57	0.36
48	0.60	4.52	0.18
72	0.31	2.65	0.09

The authors suggest that, with cotton, reentry can be safely made 12 to 24 hr after spraying with parathion-methyl parathion mixtures.

Roan et al. (1969)[1] made a study of blood cholinesterase, serum parathion concentrations, and urine p-nitrophenol concentrations in exposed individuals. They used aerial applicators, loaders, and floggers as subjects. The sprayers were using ethyl and methyl parathion. They determined that the pesticide concentration correlated well with p-nitrophenol concentrations. They found that erythrocyte and/or plasma cholinesterase values are not as sensitive as indices of ethyl and methyl parathion absorption as are the concentrations of these compounds in serum. They concluded that there are extreme differences in individual susceptibility to the actions of organic-phosphorus compounds.

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[1] Roan, C. C., D. P. Morgan, N. Cook, and E. H. Paschal, "Blood Cholinesterases, Serum Parathion Concentrations and Urine p-Nitrophenol Concentrations in Exposed Individuals." Bull. Environ. Contam. Toxicol., 4(6):362-369 (1969).

Manufacturing operations - Only one reference was found with information on repeated exposures to methyl parathion in manufacturing plants. Hartwell and Hayes (1965)[1/] made observations over a 4-year period on two plants. Both plants produced parathion and methyl parathion. The respiratory protection in both plants was quite different in adequacy at the beginning of their observations in 1960. Plant A was substandard in operation. Ventilation was inadequate and loading of the pesticide mixer was manual. Plant B was considered a modern facility. The ventilation was adequate, only nontoxic dusts were handled manually, and the insecticide concentrates were forced into the mixer by compressed air.

Poisoning cases were identified by symptoms and depression of cholinesterase levels by 20% or more. In Plant A in 1960 there were 17 cases of poisoning, and depressed cholinesterase levels (20% or more) were noted 41 times in 26 workers. In 1961 an uncontaminated compressed air system was installed allowing the replacement of the filter masks used by the workers. No poisoning cases occurred and the RBC cholinesterase activity was depressed four times among 13 workers. Depression was detected seven times in 1962 among 15 workers and six times in 1963 among 11 workers.

Although Plant B was a modern plant, it had to stop production in 1960 because of the occurrence of poisoning cases. The air compressor in this plant supplied air to the workers and was used simultaneously for forcing concentrates to the mixer. In 1961 seven cases of poisoning and nine depressions in cholinesterase activity were observed in 23 workers. The picture did not improve until 1963. In that year, a compressor was provided for each operation; the number of poisoning cases fell to zero and only three instances of depressed cholinesterase activity were observed.

[1/] Hartwell, W. V., and G. R. Hayes, Jr., "Respiratory Exposure to Organic Phosphorus Insecticides," Arch. Environ. Health, 11: 564-568 (1965).

A study has been made of the contamination of special clothing and skin coverings of workers in the manufacture of methyl parathion (Trefilov et al., 1971[1]). In general, the permissible concentration of methyl parathion in the air was not exceeded. The workers wore gas masks during the shifts. Dermal contamination was picked up from contaminated equipment. Residues were picked up around the wrists. Lesser residues were found on the chest and forehead areas. A significant depression of cholinesterase was found in the workers. Heinz bodies were found in the erythrocytes and p-nitrophenol was detected in the urine.

Accidents - Methyl parathion is one of the pesticides most frequently cited in incidents involving accidental exposure to pesticides. Preliminary data from the EPA Pesticide Accident Surveillance System (PASS)* shows that methyl parathion is the fifth most frequently cited pesticide for all episodes reported in 1973. Based on an analysis of PASS data, Osmun (1974)[2] stated that for 1972 and 1973, about 78% of the episodes reported related to agricultural jobs and involving pesticides for which reentry times have been proposed involved methyl parathion and/or parathion.

There are a number of limitations, however, in attempting to use PASS data. First of all, the cause-effect relationship between the pesticides cited and the effects observed have generally not been established. Second, generally only data for 1972 through about January 1974 have been computerized and are readily available for retrieval. Third, a large portion of the data provided to PASS comes from California. This skewed distribution probably represents bias caused by the efficient level with which the State of California documents pesticide information. During our review of PASS files, data in addition to the preliminary information found on the pesticide episode reporting form (Form ACEC-1 Dec 1972) were found on only nine of the approximately 125 episodes involving methyl parathion. Further duplicate entries in PASS have been noted for a few incidents.

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* Episodes reported include those involving humans, animals, plants, and area contamination.

[1] Trefilov, V. N., Jr., I. S. Faernan, Jr., and E. P. Borisona, Jr., "The Degree of Contamination of the Special Clothing and Skin Coverings of Workers in the Manufacture of Metaphos and Chlorophos," Gigiena Truda I Prof. Zobolevoniga, 15(2):51-53 (1971).

[2] Osmun, J. V., Internal EPA Memo to Ed Johnson, "PASS Information Relating to Agricultural Jobs" (1 April 1974).

Some 125 episodes involving methyl parathion are included in the PASS computerized system. Approximately 45, 30, and 15% of these episodes were reported from EPA Regions IV, VI, and IX, respectively. This distribution is not inconsistent with that of the domestic consumption pattern discussed later under the subsection "Production and Use."

On 10 June 1974, protection standards for agricultural workers in fields treated with methyl parathion became effective (Quarles, 1974[1]). These standards prohibit application of methyl parathion when unprotected workers are in the area being treated, and require that unprotected workers not enter fields treated with this pesticide for at least 48 hr.

Summary of Toxic Effects Other Than Acute, Subacute, and Chronic Toxicity

In one study on the effect of methyl parathion on reproduction (rats), it was noted that reproductive performance was not reduced at a dosage of 10 ppm, but was consistently reduced at 30 ppm. In another study it was shown that a daily intake of 60 ppm reduces the hatchability of quail eggs.

The teratogenic effects of methyl parathion have been studied in rats. In one study no gross anomalies were produced in the embryo or in the young when the mothers were injected with 4 and 6 mg/kg of methyl parathion. Another investigation did not indicate any malformation of young rats when the dosage was raised to 15 mg/kg of body weight. Lethality, suppression of growth and some teratogenic effects were produced in the young of mice when the injected dosage was raised to 60 mg/kg. The significant malformation was cleft palate at the 60 mg/kg of body weight dose level. Some incidence of cervical rib variation occurred at 60 mg/kg, and it was significant at the 5% level.

There was no data found on avian embryotoxicity. There were also no reports found on the possible oncogenic effects of methyl parathion.

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[1] Quarles, J., "Worker Protection Standards for Agricultural Pesticides," Federal Register, 39(62):16888-16891 (10 May 1974).

Methyl parathion does affect cell growth in tissue culture after treatment with 25 to 100 μg/ml. At the higher level (100 μg/ml) all the cells die in 1 day.

No chromosome aberrations were found in bone marrow cells of mice that had been injected with 5, 10, and 20 mg/kg of body weight of methyl parathion.

The number of reports that have been published in the literature on the effect of methyl parathion in humans is surprisingly small. No information was found to indicate the lethal dose of methyl parathion for man. It is known that humans can tolerate 20 mg of methyl parathion daily for 4 weeks without any significant changes in plasma or RBC cholinesterase levels.

The depression of blood cholinesterase activity is a sensitive diagnostic tool; pathology observed at autopsy is not gross in nature.

No information was final with regard to controlled dermal or inhalation exposure to humans.

The symptoms of methyl parathion poisoning have been delineated in a number of reports. The progress of the symptomatology appears to be quite similar to other organosphosphorus compounds. The symptoms are of an acute nature, and chronic symptoms are only mild manifestations of the acute symptoms.

It has been shown that there are exposure hazards to workers if sprayed cotton fields are entered shortly after an application of methyl parathion. Very little information is available on the hazards that may prevail in manufacturing operations. It is reasonable to assume that the wearing of protective clothing and efficient respirators along with the observance of good manufacturing practice will eliminate to a significant extent the risk involved in these operations.

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SUBPART II. C. FATE AND SIGNIFICANCE IN THE ENVIRONMENT

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This section contains data on the environmental impact of methyl parathion. Laboratory and field studies investigated effects on aquatic species, lower aquatic organisms and wildlife. Studies also evaluated methyl parathion's effects on beneficial insects, interactions with lower terrestrial organisms and effects on residues in soil, water, air and nontarget plants. The section summarizes rather than interprets data reviewed.

Effects on Aquatic Species

Fish -

Laboratory studies - The toxicity of methyl parathion to fish has been tested in a large number of species (Table 14). The scientific names are given in Table 15.

Of the species tested, the range in sensitivity of freshwater fish to methyl parathion (96-hr LC_{50} values) is from the most sensitive (bluegill LC_{50} 1.9 ppm) to the least sensitive (fathead minnow LC_{50} 8 to 10.4 ppm and the carp LC_{50} 7.13 ppm). There was one high value (LD_{50} 24 hr) reported for pumpkinseed sunfish (2,500 mg/kg). It should be noted that this LD_{50} value was obtained through an intraperitoneal injection technique and cannot be considered comparable to either LC_{50} values or to conventional LD_{50} values derived from introducing a chemical direction into the stomach via gavage.

For estuarine and saltwater fishes tested, the range in 96-hr LC_{50} values is from 5.7 ppm for the Atlantic silverside to 75.8 ppm for the Northern puffer.

The relationship of brain AChE inhibition to death after exposure to methyl parathion was determined by Coppage (1972)[1] following single exposure to acute doses that killed 40 to 60% of sheepshead minnows.

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[1] Coppage, D. L., "Organophosphate Pesticides: Specific Level of Brain AChE Inhibition Related to Death in Sheepshead Minnows," Trans. Am. Fish. Soc., 101(3):534-536 (1972).

Table 14. ACUTE TOXICITY TO FISH

Fish	Exposure time (hr)	Toxicity effect calculated by	Toxicity level measured as (ppm)	Reference
Bluegill	96	LC_{55}	1.6	l/
Bluegill	24	LC_{50}	6.47	a/
Bluegill	96	TL_m	5.72	b/
Bluegill	96	TL_m	1.90	c/
Rainbow trout	96	TL_m	2.75	b/
Brown trout	96	TL_m	4.74	b/
Yellow perch	96	TL_m	3.06	b/
Redear sunfish	96	TL_m	5.17	b/
Sunfish (pumpkinseed)	24	LD_{50}	>2,500 ppm	d/
Largemouth bass	96	TL_m	5.22	b/
Coho salmon	96	TL_m	5.30	b/
Channel catfish	96	TL_m	5.71	b/
Channel catfish	24	LC_{50}	9.36	e/
Black bullhead	96	TL_m	6.64	b/
Carp	96	TL_m	7.13	b/
Fathead minnow	96	TL_m	8.90	b/
Fathead minnow	96	TL_m	8.0	c/
Fathead minnow	96	TL_m	10.4	f/
Goldfish	96	TL_m	9.0	b/
Goldfish	96	TL_m	9.6	c/
Guppy	96	TL_m	7.8	c/
Atlantic silverside	96	LC_{50}	5.7	g/
Bluehead	96	LC_{50}	12.3	g/
Striped killifish	96	LC_{50}	13.8	g/
Mummichog	96	LC_{50}	58.0	g/
Northern puffer	96	LC_{50}	75.8	g/
Northern puffer	16 Days	Total mortality	0.02 (20.2 ppb)	h/
Siamese fighting fish	120	LC_{50}	7.6	i/
American eel	96	LC_{50}	16.9	j/
Mosquitofish	96	LC_{50}	0.005	l/
Golden shiner	48	LC_{50}	75.0	k/
Green sunfish	48	LC_{50}	>5.0	k/

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a/ McCann, J. A., and R. L. Jasper, "Vertebral Damage to Bluegills Exposed to Acutely Toxic Levels of Pesticides," *Trans. Am. Fish. Soc.*, 101(2):317-322 (1972).

b/ Macek, K. J., and W. A. McAllister, "Insecticide Susceptibility of Some Common Fish Family Representatives," *Trans. Am. Fish. Soc.*, 99(1):20-27 (1970).

c/ Pickering, Q. H., C. Henderson, and A. E. Lemke, "The Toxicity of Organic Phosphorus Insecticides to Different Species of Warm-Water Fishes," *Trans. Am. Fish. Soc.*, 91(2):175-184 (1962).

d/ Benke, G. M., K. L. Cheever, F. E. Mirer, and S. D. Murphy, "Comparative Toxicity Anticholinesterase Action and Metabolism of Methyl Parathion in Sunfish and Mice," *Toxicol. Appl. Pharmacol.*, 28:97-109 (1974).

e/ Carter, F. L., "*In vivo* Studias of Brain Acetylcholinesterase Inhibition by Organophosphate and Carbamate Insecticides in Fish," *Diss. Abstr.*, 32(5):27, 2-73 (1971).

f/ Henderson, D., and Q. H. Pickering, "Toxicity of Organic Phosphorus Insecticides to Fish," *Trans. Am. Fish. Soc.*, 87:39-51 (1958).

g/ Eisler, R., "Acute Toxicities of Organochlorine and Organophosphorus Insecticides to Estuarine Fishes," *Technical Papers of the Bureau of Sport Fisheries and Wildlife*, No. 46, pp. 1-12 (March 1970a).

h/ Eisler, R., "Tissue Changes in Puffers Exposed to Methoxychlor and Methyl Parathion," *Technical Papers of the Bureau of Sport Fisheries and Wildlife*, No. 17, pp. 1-15 (September 1967).

i/ Welsh, M. J., and C. W. Hanselka, "Toxicity and Sublethal Effects of Methyl Parathion on Behavior of Siamese Fighting Fish (*Betta splendens*)," *Tex. J. Sci.*, 23(4):519-529 (1972).

j/ Muncy, R. J., and A. D. Oliver Jr., "Toxicity of 10 Insecticides to the Red Crawfish, *Procambarus clark* (Girard). *Trans. Am. Fish. Soc.*, 92:428-431 (1963).

k/ Minchew, C. D. and D. E. Ferguson, "Toxicities of Six Insecticides to Resistant and Susceptible Green Sunfish and Golden Shiners in Static Bioassays," *J. Miss. Acad. Sci.*, 15:29-32 (1970).

l/ Carter, F. L., and J. B. Graves, "Measuring Effects of Insecticides on Aquatic Animals," *LA Agr.*, 16(2):14-15 (1973).

Table 15. COMMON AND SCIENTIFIC NAMES OF FISH USED IN CONTROLLED TOXICITY TESTS WITH METHYL PARATHION

Common name	Scientific name
American eel	*Anguilla rostrata*
Bluegill sunfish	*Lepomis macrochirus*
Rainbow trout	*Salmo gairdneri*
Brown trout	*Salmo trutta*
Yellow perch	*Perca flavescens*
Redear sunfish	*Lepomis microlophus*
Pumpkinseed sunfish	*Lepomis gibbosus*
Largemouth bass	*Micropterus salmoides*
Coho salmon	*Oncorhynchus kisutch*
Channel catfish	*Ictalurus punctatus*
Black bullhead	*Ictalurus melas*
Carp	*Cyprinus carpio*
Fathead minnow	*Pimephales promelas*
Goldfish	*Carassius auratus*
Guppy	*Lebistes reticulatus*
Atlantic silverside	*Menidia menidia*
Bluehead	*Thalassoma bifasciatum*
Striped killifish	*Fundulus majalis*
Mummichog	*Fundulus heteroclitus*
Northern puffer	*Sphoeroides maculatus*
Tilapia	*Tilapia aurea*
Siamese fighting fish	*Betta splendens*
Mosquitofish	*Gambusia affinis*
Green sunfish	*Lepomis cyanellus*
Golden shiner	*Notemigonus crysoleucas*

In exposures up to 72 hr, the lethal brain AChE level was determined to be 18% of normal. Further, Coppage stated that "... . AChE activity below this level (18% of normal) indicates death from organophosphate poisoning has occurred or will occur within about 24 hr."

In general the signs and pathology following methyl parathion poisoning of fish are similar to those induced by other organic-phosphorus insecticides (e.g., parathion). From the description in two fish studies (Henderson and Pickering, 1958;[2] Carter, 1971)[3] the following changes can be expected to occur in fish after ingestion or exposure to a lethal dose of methyl parathion: darkening of the skin, hyperactivity, body tremors, lethargy, scalosis, loss of equilibrium, opercular or gaping paralysis, and death.

One response that may be considered to be somewhat characteristic of acute poisoning of fish with methyl parathion (and perhaps other organic-phosphorus insecticides) is the extreme forward position of the pectoral and pelvic fins when the fish are intoxicated.

McCann and Jasper (1972)[4] observed hemorrhaging in bluegill fingerlings exposed to methyl parathion at levels ranging from 3.9 to 6.9 ppm. Fractures of the caudal vertebrae were associated with the hemorrhaging. The injuries were observed at dose levels both above and below the LC_{50} (6.47 ppm). The excitability of the fish was also affected. Disturbance of the fish in the early hours of exposure led to increased mortality and increased hemorrhage rate.

Field studies - Most of the data available on the toxicity of methyl parathion to fish under field conditions orginate from the use of this insecticide for the control of the Clear Lake gnat (*Chaoborus astictopus*), in Clear Lake, Lake County, California.

Hazeltine (1963)[1] determined the following toxicity data for methyl parathion: newly hatched first instar Clear Lake gnat larvae, 24-hr exposure, LC_{90}, 0.0015 ppm; fourth instar larvae, 24-hr exposure, 0.021 ppm; bluegill sunfish, 10-day exposure, LC_{50}, 0.115 ppm. The bluegill sunfish (*Lepomis macrochirus*) was selected as the test organism because it had been shown in previous tests to be the species most susceptible to organophosphate insecticides in the lake fish population. These data indicated a substantial safety margin between the rate of methyl parathion necessary for insect control and concentrations that would harm fish.

---

[1] Hazeltine, W. E., "The Development of a New Concept for Control of the Clear Lake Gnat," *J. Econ. Entomol.* 56(5):621-626 (1963).

[2] Henderson, C., and Q. H. Pickering, "Toxicity of Organic Phosphorus Insecticides to Fish," *Trans. Am. Fish. Soc.*, 87:39-51 (1958).

[3] Carter, F. L., "*In vivo* Studies of Brain Acetylcholinesterase Inhibition by Organophosphate and Carbamate Insecticides in Fish," *Diss. Abstr.* 32(5):27, 2-73 (1971).

[4] McCann, J. A., and R. L. Jasper, "Vertebral Damage to Bluegills Exposed to Acutely Toxic Levels of Pesticides," *Trans. Am. Fish. Soc.*, 101 (2):317-322 (1972).

Methyl parathion was subsequently applied repeatedly to Clear Lake at doses of .0023 and .0033 ppm. Cook and Conners (1963)[1] made extensive studies on the effects of these methyl parathion treatments on fish and other aquatic organisms in the treated area. They gave no numerical data, but concluded that the insecticide treatments had minimal or no adverse effect on some 20 species of fish that had been recorded to be present in the lake in previous studies.

Cook (1965)[2] reported that none of the species of fish in Clear Lake utilized gnat larvae as their principal food item, with the possible exception of the Sacramento perch (Archoplites interruptus) based on the examination of over 2,000 stomach contents from all species of fish in the lake.

Mulla et al. (1963)[3] investigated the toxicity of methyl parathion and other insecticides to some aquatic wildlife species, including the mosquitofish (Gambusia affinis). Methyl parathion was applied to 1/16-acre field ponds at a volume of 8 gal/acre as an aqueous spray prepared from an emulsion concentrate containing 7.5 lb AI/gal. At the rate of 0.8 lb AI/acre, methyl parathion produced 10% mortality of mosquitofish 1 and 2 days after treatment. At the rate of 0.4 lb AI/acre, mosquitofish mortality was zero 1 day after treatment, 2% after 2 days. All mosquito fish survived a methyl parathion application at the rate of 0.1 lb AI/acre.

Macek and McAllister[4] (1970) conducted 96-hour static bioassays using several pesticides, including methyl parathion, on several representative species of four fish families to determine the relative susceptibility of these species to different pesticides. Reconstituted, deionized water at a temperature of 13±0.5 C for salmonids and 18±0.5 C for other fish was used. Weight of test fish ranged from 0.6 to 1.7 grams. All LC_{50} values are based on the active ingredient of the formulations used. Results are presented in Table 14.

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[1] Cook, S. F., Jr., and J. D. Conners, "The Short-Term Side Effects of the Insecticidal Treatment of Clear Lake, Lake County, California, in 1962," Annals of the Entomol. Soc. of America, 56(6):819-824 (1963).

[2] Cook, S. F., Jr., "The Clear Lake Gnat: Its Control, Past, Present, and Future," California Vector Views, 12(9):43-47 (1965).

[3] Mulla, M. S., L. W. Isaak, and H. Axelrod, "Field Studies on the Effects of Insecticides on Some Aquatic Wildlife Species," J. Econ. Entomol., 56(2):184-188 (1963).

[4] Macek, K. J., and W. A. McAllister, "Insecticide Suspectibility of Some Common Fish Family Representatives," Trans. Am. Fish. Soc., 99(1):20-27 (1970).

Ferguson and Boyd (1964)[1] exposed mosquitofish (Gambusia affinis) from two different locations to various rates of methyl parathion. Resistance of mosquitofish to chlorinated hydrocarbon insecticides had been reported in populations living near heavily sprayed cotton fields in western Mississippi. The mosquitofish population from an area of heavy use of cotton insecticides (Leflore County, Mississippi) was considerably less susceptible to methyl parathion than a control population known to be nonresistant at least to chlorinated hydrocarbon insecticides.

Carter[2] showed, in a field study of channel catfish, Ictalurus punctatus, in waters in a drainage area of a cotton-soybean agroecosystem receiving 8 to 16 yearly applications of methyl parathion (0.45 to 0.89 kg/ha), fish contained residues of methyl parathion and he showed brain-AChE inhibition in other fishes.

The Federal Water Pollution Control Administration's publication "Water Quality Criteria" (1968)[3] places methyl parathion in the category "other pesticides." This group includes approximately 100 pesticides in general use for which data on the acute toxicity to aquatic organisms are available. "These chemicals are either not likely to reach the marine environment, or if used as directed by the registered label, probably would not occur at levels toxic to marine biota. It is presumed that criteria established for these chemicals in freshwater will protect adequately the marine habitat."

The 48-hr TL_m of methyl parathion to bluegill is listed as 8,000 ug/liter (8 ppm), compared to 47 ug/liter (0.47 ppm) for parathion (Federal Water Pollution Control Administration, 1968).

Minchew and Ferguson[4] (1970) studied acute effects of several pesticides, including methyl parathion, on susceptible and resistant populations of green sunfish (Lepomis cyanellus) and golden shiner (Notemigonus crysoleucas) by running 48-hr static bioassays.

For each concentration tested, 20 fish were placed in each of two 30 l aquaria. Four or five concentrations were tested to calculate each median lethal concentrations (LC_{50}). Tap water was used in all bioassays; water temperature was 68 ± 4 F (20 ± 2.2C). Estimated LC_{50} values were greater than 5 ppm for susceptible populations of both green sunfish and golden shiner.

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[1] Ferguson, D. E., and C. E. Boyd, "Apparent Resistance to Methyl Parathion in Mosquitofish, Gambusia affinis," Copeia No. 4:706 (1964).

[2] Carter, F. L., "In vivo Studies of Brain Acetylcholinesterase Inhibition by Organophosphate and Carbamate Insecticides in Fish," Diss. Abstr., 32(5):27, 2-73 (1971).

[3] Federal Water Pollution Control Administration, Water Quality Criteria, Report of the National Technical Advisory Committee, p. 37 (1968).

[4] Minchew, C. D. and D. E. Ferguson, "Toxicities of six insecticides to resistant and susceptible green sunfish and golden shiners in static bioassays," J. Miss. Acad. Sci., 15:29-32 (1970).

In a study reported by Kennedy and Eller (1969)[1] the chronic toxicity of methyl parathion was determined for catfish and goldfish. One hundred fish of each species were stocked in separate ponds. The ponds were treated with 200 ppb (0.2 ppm) methyl parathion and sampled at the following times: pretreatment, 1, 3, 7, 14, 28, 56, and 84 days. During the experimental period the total fish loss was 6% for goldfish and 8% for catfish. This was considered normal mortality and presumably compared favorably with observed mortality in the untreated ponds.

None of the fish showed signs of distress after treatment. The pathology of catfish liver was characterized by marked cytoplasmic vacuolization of hepatic cells. A sharp increase in cytoplasmic granularity of hepatic cells characterized liver damage in the goldfish. Examination of control fish and fish given multiple exposures of methyl parathion were incomplete at the time of presentation of the data.

These data indicate that methyl parathion is considerably less toxic to fish than parathion.

Lower Aquatic Organisms -

Laboratory studies - In a study on red crawfish, Muncy and Oliver (1963)[2] reported that there was no detectable difference in the toxicity of methyl parathion to male or female crawfish although methyl parathion was found to be very toxic to these crustaceans (Table 16). They reported that the reaction to the presence of methyl parathion was evident in red crawfish at less than 1 ppm and that death occurred in less than 3 hr. The 72-hr median tolerance limit (TL_m) was determined to be 0.04 ppm.

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[1] Kennedy, H. D., and L. L. Eller, "Chronic Effects of Methyl Parathion and Endrin on Channel Catfish and Goldfish in Ponds," in Progress in Sport Fishery Research: 1968, U. S. Bureau of Sport Fisheries and Wildlife, Division of Fishery Research, Resource Publication No. 77, 103-107 (1969).

[2] Muncy, R. J., and A. D. Oliver, Jr., "Toxicity of 10 Insecticides to the Red Crawfish, *Procambarus clarki* (Girard)," Trans. Am. Fish. Soc., 92:428-431 (1963).

The acute toxicity values (LC_{50} 96 hr) of methyl parathion for the sand shrimp, grass shrimp, freshwater shrimp, and for the hermit crab (Eisler, 1969 [1] and 1970b) was 0.002, 0.003, 0.011, and 0.007 ppm, respectively.

In contrast to the lability of methyl parathion on crops, Eisler (1970a) reported that in brackish water a concentration of methyl parathion of 0.5 ppm remained toxic for young blue crabs and juvenile brown shrimp for at least 45 days.

Albaugh (1972) [2] studied the difference in susceptibility of crayfish (*Procambarus acutus*) taken from clean water as compared to crayfish taken from water containing runoff from cotton fields. The 48-hr LC_{50} for the clean area crayfish was 2.4 ppb (.0024 ppm) (range 1.9 to .0034 ppm) while that for crayfish from the cotton field area was 3.4 ppb (range 3.0 to 4.0). The small difference presumably results from selective pressure due to environmental exposure rather than true resistance to methyl parathion.

Field studies - The Federal Water Pollution Control Administration's publication *Water Quality Criteria* (1968) [3] lists the 48-hr TL_m values of methyl parathion to the water flea (*Daphnia magna*) as 4.8 ug/liter (.0048 ppm).

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[1] Eisler, R., "Acute Toxicities of Insecticides to Marine Decapod Crustaceans," *Crustaceana*, 16(3):302-310 (1969).

[2] Albaugh, D. W., "Insecticide Tolerances of Two Crayfish Populations (*Procambarus acutus*) in South-Central Texas," *Bull. Environ. Contam. Toxicol.*, 8(6):334-338 (1972).

[3] Federal Water Pollution Control Administration, "Water Quality Criteria," *Report of the National Technical Advisory Committee*, p. 37 (1968).

Table 16. ACUTE TOXICITY - AQUATIC INVERTEBRATES

Fish[a]	Exposure time (hr)	Toxicity effect calculated by	Toxicity level measured by (ppm)	References
Red crayfish	24	TL_m	0.05	b/
Red crayfish	48	TL_m	0.04	b/
Red crayfish	72	TL_m	0.04	b/
Sand shrimp	96	LC_{50}	0.002	c/
Grass shrimp	96	LC_{50}	0.003	c/
Hermit crab	96	LC_{50}	0.007	c/
Freshwater shrimp	24	LD_{50}	0.011	d/
Daphnia magna	48	TL_m	0.0048	e/
White River Crayfish	96	LC_{50}	0.003	f/
Procambarus acutus	48	LC_{50}	0.0024 and 0.0034	g/

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a/ Common and scientific names of aquatic species other than fish:

Hermit crab	*Pagurus longicarpus*
Blue crab	*Callinectes sapidus*
Brown shrimp	*Penaeus aztecus*
Freshwater shrimp	*Palaemonetes kadiakensis*
Water flea	*Daphnia magna*
White river crayfish (not given)	*Procambarus acutus*

b/ Muncy and Oliver, *op. cit.* (1963).

c/ Eisler, *op. cit.* (1969).

d/ Naqvi, S.M., and D.E. Ferguson, "Levels of Insecticide Resistance in Freshwater Shrimp, *Palaemonetes kadiakensis*," *Trans. Am. Fish. Soc.*, 99:696-699 (1970).

e/ Federal Water Pollution Control Administration, *Water Quality Criteria. Report of the National Technical Advisory Committee*, p. 37 (1968).

f/ Carter, F.L., and J.B. Graves, "Measuring Effects of Insecticides on Aquatic Animals," *LA Agr.*, 16(2):14-15 (1973).

g/ Albaugh, D.W., "Insecticide Tolerances of Two Crayfish Populations (*Procambarus acutus*) in South-Central Texas," *Bull. Environ. Contam. Toxicol.*, 8(6):334-338 (1972).

A study of the acute (5 day) toxicity of methyl parathion to Louisiana red crawfish (Procambarus clarki) was performed by Hendrick and Everett (1965). 1/ The 5-day median tolerance limit (TL_m) was determined to be $<$ 10 ppt.

There is little information on the symptoms of methyl parathion poisoning in aquatic animals other than fish. One report describes some of the symptoms exhibited by clams when exposed to methyl parathion (Eisler, 1970b 2/). An excessive production of mucus will occur, the siphons will be extended, there will be gaping valves and sluggishness which can be determined by lack of response to mechanical stimulation.

Carter and Graves (1973) 3/ (Table 16) studied the toxicity of methyl parathion to White River crawfish, three species of fish (Table 14), and bullfrog tadpoles. Bullfrog tadpoles had a 96 hr LC_{50} of 6.4 ppm. Crawfish were most sensitive to methyl parathion and other pesticides tested, while the bullfrog tadpoles were least sensitive. When LC_{50}'s were compared, methyl parathion was 2,033 times more toxic to crawfish than to the tadpoles. Among the fish species tested, bluegill was the most sensitive. The authors concluded that higher animals are less sensitive to the insecticides tested than are lower forms, and that responses vary by species.

Naqvi et al (1969)4/ investigated the toxicity of methyl parathion to four populations of the fresh-water shrimp (Palaemonetes kadiakensis). Ten shrimp were placed in 3.79 liter glass jars. Three replicates were made to obtain average mortality for 30 shrimp at each concentration tested.

Of the fresh-water shrimp populations tested, three were from areas of high pesticide usage. They were (1) a drainage ditch near Hollandale, Mississippi; (2) a 0.5 acre pond near Belzini, Mississippi; and (3) a 640 acre lake (Sky Lake), Mississippi.

These were compared to fresh-water shrimp from Bluff Lake on the Noxubee National Wildlife Refuge. The 24-hr median lethal concentration (ppm) for the different populations are given below;

1/ Hendrick, R. D., and T. R. Everett, "Toxicity to the Louisiana Red Crawfish of Some Pesticides Used in Rice Culture," J. Econ. Entomol., 58:958-961 (1965).

2/ Eisler, R., "Latent Effects of Insecticide Intoxication to Marine Molluscs." Hydrobiologia, 36:345-352 (1970b).

3/ Carter, F. L., and J. B. Graves, "Measuring Effects of Insecticides on Aquatic Animals," LA Agr., 16(2):14-15 (1973).

4/ Naqvi, S. M., and D. E. Ferguson, "Levels of Insecticide Resistance in Freshwater Shrimp, Palaemonetes kadiakensis," Trans. Am. Fish. Soc., 99:696-699 (1970).

Naqvi and Ferguson (1969) [1] collected tubificid worms (Tubifex tubifex) from an area of high pesticide use (Belzoni, Mississippi). After separation from the bottom mud, they were exposed in tap water for 72 hours to concentrations of 6 ppm methyl parathion. No mortalities occurred at this concentration.

The author suggested that animals (i.e. Tubifex) which are able to tolerate and presumably store large body burdens of toxicants such as methyl parathion may present a hazard to higher trophic levels.

Two of the three exposed population have higher median lethal concentrations than the one relatively unexposed population (Bluff Lake). One (Sky Lake) has a lower median lethal concentration. The author concluded that generally resistance was absent or weak toward organophosphorus insecticides as compared with organochlorine and carbamate insecticides tested.

Bluff Lake	Hollandale	Belzoni	Sky Lake
0.0037	0.0141	0.230	0.0025

Mulla et al. (1963) [2] studied the toxicity of methyl parathion and other insecticides to the tadpoles of the Western toad (Bufo boreas), and Hammond's spadefoot toad (Scaphiopus hammondi). Methyl parathion was applied to 1/16-acre field ponds at a volume of 8 gal/acre as an aqueous spray prepared from an emulsion concentrate containing 7.5 lb AI/gal. At application rates of 0.1 and 0.4 lb AI/acre, methyl parathion caused no mortalities to the tadpoles on 24-hr exposure.

Cook and Conners (1963) [3] studied the effects on the lake biota of mosquito control applications of methyl parathion at the rate of 3 ppb (0.003 ppm) to Clear Lake, Lake County, California, to control the Clear Lake gnat (Chaoborus astictopus). In the summer of 1962, methyl parathion was applied to the lake three times, once each in June, July, and August. Open lake water was sampled for plankton by a standard plankton tow net. In the laboratory, the plankton was identified, usually to genus, and visual estimates were made as to the relative frequency of each. Samples were then spun down in a clinical centrifuge where the phytoplankton and zooplankton would separate due to their different densities. Benthic samples were taken by means of an Eckman dredge. Bottom mud was sifted and the benthic fauna transferred to a collecting jar and counted.

1/ Naqvi, S. M. and D. E. Ferguson. "Pesticide tolerances of selected freshwater invertebrates", J. Miss. Acad. Sci., 14:121-127 (1969).

2/ Mulla, M. S., L. W. Isaak, and H. Axelrod, "Field Studies on the Effects of Insecticides on Some Aquatic Wildlife Species," J. Econ. Entomol., 56(2):184-188 (1963).

3/ Cook, S. F., Jr., and J. D. Conners, "The Short-Term Side Effects of the Insecticidal Treatment of Clear Lake, Lake County, California, in 1962", Ann. Entomol. Soc. Am., 56(6):819-824 (1963).

Because there was only one other year in which data were collected pertaining to plankton and benthic organisms, it could not be determined whether observed variations are within the normal range of variability that could be expected under these environmental conditions. However, there was an immediate decrease in zooplankton population following the second and third treatments. The zooplankton also failed to exhibit the population explosion which was evident during September and October the previous year. During this period of lower-than-expected zooplankton populations, there was a bloom of the phyloplankton species Anabaena.

It is not known whether further studies were done to clarify if variations in the zooplankton populations were within the normal range of population variation or were a result of the methyl parathion applications. Further study is needed on the effects of methyl parathion on zooplankton, especially to Daphnia and Cyclops. The TL_m reported earlier (Fed. Water Poll. Adm., 1968) for Daphnia magna as .0048 ppm, is close to the concentration applied (.003 ppm).

From the data previously collected on benthic organisms, especially the midge Chaoborus, there seemed to be no significant change in benthic populations.

No harmful effects to fish populations were observed. There was no significant increase in mortality of adults or fry and no significant depression of brain cholinesterase levels after applications of methyl parathion occurred.

The authors conclude from the wealth of data acquired in this manner that the methyl parathion treatments of Clear Lake had generally a minimal influence on the biota of the lake, with the exception of the target insect, the Clear Lake gnat, and perhaps species of the zooplankton.

Hendrick et al (1966)1/ studied the effect of methyl parathion on the red crayfish (Procambarus clarki) in a flooded rice field at Crowley, Louisiana, where the rearing of crayfish in rice fields is of considerable commercial importance. Four replicate plots, 41 by 41 feet, were used. Each has separate drainage and is separated from adjacent plots by an 18-inch levee and fence, which effectively restricts the test plots. Alkalinity, ph, dissolved oxygen, and CO_2 were recorded and showed no difference resulting from treatments in any sampling period. Data on weight and length were taken eight times between August 15, 1963 and April 28, 1964. Ground operated spray equipment was used to deliver 4 gallons of methyl parathion solution per acre on August 23, 1963. This delivered 0.25 lb. methyl parathion per acre, which resulted in a calculated concentration of more than 100 ppb in 6 acre-in of rice field water.

1/ Hendrick, R. D., T. R. Everett, and H. R. Caffey. "Effects of some insecticides on the survival, reproduction and growth of the Louisiana red crawfish." J. Econ. Entomol. 59:188-192 (1966).

No symptoms of acute toxicity were observed during the test period. An analysis of the data showed no significant difference in either the number or weight of crayfish harvested form treated and control plot. The author concluded that applications of methyl parathion resulted in no measurable effect on survival, growth, and reproduction of the red crayfish at the rate tested.

Additional reports on the interactions between methyl parathion and lower aquatic organisms were not found. The data that was reviewed in this section indicates that the pattern of toxicity of methyl parathion to aquatic organisms is similar to that of parathion. Methyl parathion appears to be extremely toxic to aquatic insects, toxic to the lower aquatic fauna, and relatively nontoxic to the lower aquatic flora. Methyl parathion is considerably less persistent than parathion in lake, river and field waters. Thus, its effects on lower aquatic organisms would be expected to be less prolonged than those that might be caused by comparable rates of parathion.

Effects on Wildlife

Laboratory Studies - There are only a few references to studies on the toxicity of methyl parathion to wildlife; these references relate only the susceptibility of birds.

Toxicity (LD_{50}) of methyl parathion for redwing blackbirds and for starlings was reported by Schafer (1972)[1] to be 10 mg/kg and 7.5 mg/kg, respectively.

Tucker and Crabtree (1970)[2] report LD_{50}'s for mallards and pheasants to be 10.0 mg/kg (range 6.12 to 16.3) and 8.21 mg/kg (range 5.69 to 11.9) of body weight, respectively.

In a study of comparative subacute dietary toxicities of pesticide to birds, Heath et al. (1972)[3] reported that (1) Japanese quail were more susceptible to methyl parathion than bobwhite quail, (2) that both quail species were more sensitive than pheasant and (3) that the mallard duck was the least susceptible of all four species. The LC_{50} values reported in the study were:

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[1] Schafer, E. W., "The Acute Oral Toxicity of 369 Pesticidal, Pharmaceutical and Other Chemicals to Wild Birds," Toxicol. Appl. Pharmacol., 21:315-330 (1972).

[2] Tucker, R. K., and D. G. Crabtree, "Handbook of Toxicity of Pesticides to Wildlife," U.S. Department of the Interior, Fish and Wildlife Service, Denver Wildlife Research Center, Resource Publication No. 84 (1970).

[3] Heath, R. G., J. W. Spann, E. F. Hill, and J. F. Kreitzer, "Comparative Dietary Toxicities of Pesticides to Birds," Special Scientific Report, Wildlife No. 152, Bureau of Sport Fisheries and Wildlife (1972).

	LC_{50} - ppm in feed
Japanese quail	46
Bobwhite quail	90
Pheasant	116
Mallard duck	682

Shellenberger et al. (1968)[1/] found that egg production of Japanese quail was inhibited. Hatchability was reduced by 60 ppm methyl parathion. This was in contrast to parathion's reduction of hatchability at 27 ppm.

Field Studies - Robel et al. (1972)[2/] reported on the effects of methyl parathion and other insecticides on populations of wild rodents in Kansas, based on observations made from 1965 to 1969. The study was conducted on two sites in Ellis County, Kansas, in a newly created irrigation district that had not been extensively cultivated or treated with insecticides prior to 1965. No insecticidal residue were found in samples of water, soil, plants, or animals collected from the study sites prior to initiation of the study in 1965.

Methyl parathion was applied to one field (the second field served as an untreated control) at recommended and commonly used rates of application as follows: 0.38 lb AI/acre in 1966; 0.5 in 1967; 0.53 in 1968. Live rodents were trapped in the treated and control fields from 1965 through 1969. A total of 4,661 rodents were captured, of which 162 were analyzed for residues.

No methyl parathion residues were found in any of these specimens. The species composition of the trapped rodents was similar for the treated and the untreated study area, as were the population levels of Peromyscus maniculatus which comprised about 74% of the total rodent population in the two areas. Average minimal longevity for P. maniculatus and monthly survival between June and September did not differ significantly between the treated and the untreated areas. Thus, none of the parameters observed in this study indicated any effects on the wild rodent population from the use of methyl parathion at field rates over a 3-year period.

[1/] Shellenberger, T. E., J. B. Gough, and L. A. Escuriex, "Comparative Toxicity Evaluation of Organophosphate Pesticides with Wildlife," Ind. Med. Surg., 37:537 (1968).

[2/] Robel, R. J., C. D. Stalling, M. E. Westfahl, and A. M. Kadoum, "Effects of Insecticides on Populations of Rodents in Kansas - 1965-1969," Pest. Monit. J., 6(2):115-121 (1972).

McIntyre and Causey (1971)[1] collected bobwhite quail in the field in or very near to insecticide-treated soybean fields. Methyl parathion was commonly applied to these fields along with other pesticides, but no organophosphate residues were detected in the birds, while they showed very high (average 17.08 ppm) residues of DDT.

Culley and Applegate (1967)[2] determined insecticide residues in representative species of reptiles, birds, and wild mammals from Presidio, Texas. The Presidio Valley where this sampling was conducted has approximately 384,000 acres of land, of which 2,900 acres are under cultivation and pesticide treatments. The valley is at an elevation of 2,600 ft, surrounded by mountains in the United States and in Mexico rising above 7,000 to 8,000 ft. The area represents a point source of insecticide application within a large enclosed area.

Specimens of reptiles, birds, and mammals were obtained by shooting or trapping from insecticide-exposed and nonexposed areas. All specimens were kept frozen until processing and analysis. During 1965 when this study was conducted, commercial growers used 15,900 lb of methyl parathion active ingredient on the cultivated acres in the valley. Residues of methyl parathion were found in all environmental samples analyzed, including lizard tail muscle, brain tissue, liver, coelom fat, and stomach contents; sparrow breast muscle, brains, liver, and gizzards; and in leg muscles and livers of pocket mice and kangaroo rats. Methyl parathion residues generally ranged from 0.1 to 1.0 ppm; higher levels were found in a few lizard tail muscles (4.4 and 4.9 ppm); in a few samples of coelom fat of lizards (3.7 and 4.2 ppm); in lizard eggs (11.6 ppm); in all samples of sparrow breast muscle (1.6 and 5.5 ppm); in a few samples of sparrow brains (2.6, 2.8 and 3.2 ppm); and in some samples of pocket mice and kangaroo rat leg muscles (2.9, 4.0 and 4.6 ppm). In general, the farther the specimens were collected from the cotton fields, the less were the insecticide concentrations that they carried.

About 2,000 lb of parathion were used in the Presidio Valley in 1965, that is only about one-eighth of the quantity of methyl parathion used. However, residues of parathion found in the same specimens were in all instances very similar to those of methyl parathion, indicating considerably greater environmental persistence of parathion as compared to methyl parathion.

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[1] McIntyre, S. C., Jr., and M. K. Causey, "Insecticide Residues in Bobwhite Quail Associated with Alabama Soybean Production," J. Alabama Acad. Sci., 42(1):28-33 (1971).

[2] Culley, Dudley D., and Howard G. Applegate, "Insecticide Concentrations in Wildlife at Presidio, Texas," Pest. Monit. J., 2:21-28 (1967).

Applegate (1970)[1] collected samples of soil, vegetation, birds, rodents, and lizards from a large area of the Big Bend National Park, Texas, and analyzed them for insecticide residues. Samples were placed in an ice chest as quickly as possible after collection, maintained under refrigeration, and taken to Presidio, Texas, 3 to 5 days later where they were placed in deep freezers and held for 10 to 14 days in frozen storage until processing and analysis. Methyl parathion residues were found in six out of nine samples of surface soil, ranging from 0.01 to 6.34 ppm; in four out of nine samples of leatherstem (*Jatropha dioica*), ranging from 0.01 to 0.09 ppm; in 12 out of 20 samples of muscle tissue of rodents, ranging from 0.01 to 3.23 ppm; in 9 out of 19 samples of whole lizards, ranging from 0.01 to 0.70 ppm; and in 10 out of 19 samples of bird muscle, ranging from 0.01 to 7.54 ppm.

There were no known direct applications of methyl parathion in the park. The nearest areas using insecticides are all south of the park in Mexico where methyl parathion and other pesticides are being routinely applied to cotton fields. It is not known how the surprisingly high and ubiquitous methyl parathion residues in the soil and in the different animal species sampled were acquired. Drift from cotton fields, use within the park by campers or other visitors, and/or spillage in the course of unauthorized movement across the border may be responsible.

The purpose of this study was to establish a baseline for further investigations to show possible changes in the level of pesticide pollution of this park.

No other data was found on the toxicity of methyl parathion under field conditions. The data on the oral acute toxicity of methyl parathion to mallards and pheasants summarized by Tucker and Crabtree (1970) indicates that methyl parathion is significantly less toxic to these two species than its ethyl homolog, parathion.

The summary on parathion and methyl parathion by Pimentel (1971)[2] includes one additional brief report on wildlife toxicity. In a U.S. Department of Interior study (1966),[3] methyl parathion was applied at rates of 0.5 and 3.0 lb AI/acre. Pheasant mortality was about 2% at the lower rate, about 25% at the higher one.

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[1] Applegate, H. G., "Insecticides in the Big Bend National Park," *Pest. Monit. J.*, 4(1):2-7 (1970).

[2] Pimentel, D., "Ecological Effects of Pesticides on Nontarget Species," Executive Office of the President, Office of Science and Technology, U.S. Government Printing Office, Washington, D.C. (1971).

[3] United States Department of the Interior, "Wildlife Research; Problems, Programs and Progress, Pesticide-Wildlife Relations," Fish Wildlife Service, *Bureau of Sport Fish. Wildlife Circular*, No. 43, 117 pp. (1966).

Methyl parathion labels carried the warning: "Poisonous to wildlife. This product is toxic to wildlife. Birds and other wildlife in treated areas may be killed."

Effects on Beneficial Insects

The Handbook of Toxicology, Vol. III - Insecticides (Negherbon, 1959)[1] lists the LD_{50} of methyl parathion by topical application to adult worker bees (Apis mellifera) at 0.5 μg/g. In comparable tests, parathion LD_{50}'s were determined at 0.147 μg/g in one test, 3.5 μg/g in another.

Johansen (1972)[2] investigated the toxicity of field-weathered residues of methyl parathion and other insecticides to different species of bees. Methyl parathion from a 4-lb/gal emulsifiable liquid was applied to alfalfa at the rate of 0.5 lb AI/acre. Three kinds of bees were exposed to the methyl parathion residues 10 hr after application. Bee mortality was determined after 24 hr and ranged from 48 to 89% (41 to 66% for parathion under the same conditions).

These data indicate that methyl parathion is highly toxic to bees, and that its order of toxicity to this species is in the same range as that of parathion. Methyl parathion labels state: "This product is highly toxic to bees exposed to direct treatment or residues on crops." Cooperative Agricultural Extension Service recommendations in many states provide specific warnings and advice applicable to local conditions intended to prevent bee damage from the use of methyl parathion.

There is little data available regarding the effects of methyl parathion on parasites and predators.

One important report is that by Lingren et al. (1972)[1] who studied the toxicity of methyl parathion and other insecticides to two species of parasitic wasps, i.e., Apanteles marginiventris and Campoletis perdistinctus.

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[1] Negherbon, William O., "Insecticides," The Handbook of Toxicology, Vol. III, Tech. Report No. 55-16, W. B. Saunders, Phil., Pa. (1959).

[2] Johansen, C. A., "Toxicity of Field-Weathered Insecticide Residues to Four Kinds of Bees," Environ. Entomol., 1(3):393-394 (1972).

The LD_{50} of methyl parathion to adult C. perdistinctus (topical application) was 0.0004 µg/insect to males, 0.0025 µg/insect to females. In this test, methyl parathion was six times more toxic to male C. perdistinctus than parathion; a comparable toxicity value of parathion for female C. perdistinctus is not given. The LD_{50} of methyl parathion to A. marginiventris (mixed sexes) was 0.0004 µg/insect.

When the insecticides were applied topically to cocoons of the two wasp species, methyl parathion produced 9% mortality of C. perdistinctus cocoons at 0.04 µg/cocoon. In similar tests on A. marginiventris, methyl parathion produced 37% cocoon mortality at 0.03 µg/cocoon.

Methyl parathion was also highly toxic to adult male C. perdistinctus confined on caged cotton plants treated at 0.5 and 1.5 lb AI/acre in the field.

These data indicate and the field experiences of many cotton entomologists confirm that methyl parathion at commercial use rates is highly detrimental to wasps, as well as to other important parasites and predators.

Interactions with Lower Terrestrial Organisms

Matsumura and Boush (1971)[2] recently reviewed the metabolism of insecticides by microorganisms. They point out that organophosphate insecticides (including methyl parathion) have thus far apparently neither presented serious problems in soils as regards undesirable persistence, nor demonstrated an extraordinary affinity for fat with resulting concentration in food chains. Although considerable variation exists between individual organophosphates, most of them are readily degraded in soil, mainly by hydrolytic and oxidative means. A number of reports are cited which show that specific microorganisms degrade one or more organophosphates under laboratory conditions, but none of these publications deal specifically with methyl parathion.

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[1] Lingren, P. D., D. A. Wolfenbarger, J. B. Nosky, and M. Diaz, Jr., "Response of Campoletis perdistinctus and Apanteles marginiventris to Insecticides," J. Econ. Entomol., 65(5):1295-1299 (1972).

[2] Matsumura, F., and G. M. Boush, "Metabolism of Insecticides by Microorganisms," Soil Biochemistry, 2:320-336, Marcel Dekker, New York (1971).

The authors point out that no one has yet demonstrated whether or not such microbiological degradation actually occurs in nature, or even that any of these pesticides serve as nutritional or energy sources for organisms. "There are no reports as yet that these chemicals have been shown to serve as sole nutritional carbon sources."

Several publications by Naumann (1970a, 1970b, 1970c, 1971)[1-4] deal with the effects of methyl parathion on the soil microflora. Methyl parathion in the form of a wettable powder was mixed with loess black soil in field and greenhouse tests continued over a 5-year period. Methyl parathion was found to cause a significant increase in the total content of bacteria and actinomycetes at dosages 200 times higher than the concentration that would be obtained by normal field application. The bacterial stimulation following application of methyl parathion was influenced by soil temperature and humidity. Low soil temperature and low soil humidity delayed the stimulation of the bacteria. At normal application rates, the total bacterial population of the soil would be influenced only slightly by methyl parathion.

Soil applications of methyl parathion at 550 ppm or greater initially decreased the soil respiration rate as measured by the Warburg technique. However, after a few hours, the oxygen consumption increased, surpassing the respiration of untreated soil. Stimulation of oxygen consumption by methyl parathion was greater in sand and compost soil than in loam soil. In loam soil, the mineralization of glucose was increased by the addition

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[1] Naumann, K., "The Dynamics of Soil Microflora Following the Application of Plant Protection Agents. I. Field Experiments on the Effect of Methyl Parathion on the Bacterial and Ray Fungi Population of the Soil," Zentr. Bakteriol. Parasitenk., Abt. II: Naturw., 124(7): 743-754 (1970a).

[2] Naumann, K., "The Dynamics of Soil Microflora Following the Application of Plant Protection Agents. II. The Reaction of Various Physiological Groups of Soil Bacteria to the Application of Methyl Parathion in the Field," Zentr. Bakteriol. Parasitenk., Abt. II: Naturw., 124(7):755-765 (1970b).

[3] Naumann, K., "The Dynamics of the Soil Microflora after Application of Plant Protective Agents. IV. Investigations on the Effects of Methyl Parathion on Respiration and Dehydrogenase Activity of the Soil," Zentr. Bakteriol. Parasitenk., Abt. II: Naturw., 125:119-133 (1970c).

[4] Naumann, K., "Changes in the Composition of the Soil Microflora Following Application of Plant Protection Agents to the Soil," Zentr. Bakteriol. Parasitenk. Infektionskr. Hyg., Abt. II: 126(5):530-544 (1971).

of methyl parathion. Repeated methyl parathion applications at high rates showed that after the third application there was no further stimulation of the oxygen consumption per hour. The author attributes this to reaching the toxic limit. The dehydrogenase activity in loam soil treated with high rates of methyl parathion was almost completely blocked.

The effects of methyl parathion on different types of soil bacteria were studied in a 21-week test. Higher rates of methyl parathion showed more marked effects on the ammonifying and nitrifying bacteria, and lesser effects on cellulose-decomposing, anaerobic and spore-forming bacteria. The methyl parathion treatments did not affect the denitrifying bacteria or the soil algae significantly.

It appears that these effects of methyl parathion on different soil microorganisms occurred only at concentrations many times higher than those that would be encountered in normal insect control use.

Our search of the literature and of other sources failed to yield any publications dealing with the effects of specific microorganisms on the persistence of methyl parathion in the soil. However, there is every reason to believe that the soil organisms shown by a number of authors to degrade parathion will also degrade methyl parathion. Methyl parathion, like parathion, appears to be subject to both chemical and biological degradation in the soil.

Residues in Soil

Laboratory Studies - Baker and Applegate (1970)1/ determined the persistence of methyl parathion (and other pesticides) in three alkaline soils (Houston Black clay, Pima silty clay, and Pinal gravelly loam) in growth chambers at two temperatures (30 and 50°C), with and without exposure to biologically effective ultraviolet radiation. The pesticides were added to 20-g soil samples in glass Petri dishes at 5, 20 and 1,000 ppm. Pesticide residues were determined by gas chromatography at different intervals after treatment. The Soxhlet extraction method employed recovered 95 to 99% of the added pesticide.

Soils treated with methyl parathion at 5 ppm lost 46 to 48% of the initial quantity in 50 days at 30°C. Under radiation, additional losses of 10 to 14% methyl parathion occurred. After 50 days at 50°, 64 to 65% methyl parathion had disappeared; radiation increased the loss by 14 to 17%.

1/ Baker, R. D., and H. G. Applegate, "Effect of Temperature and Ultraviolet Radiation on the Persistence of Methyl Parathion and DDT in Soils," Agron. J., 62(4):509-512 (1970).

Losses after 60 days from soils treated with methyl parathion at 20 ppm were as follows: At 30°C, 51 to 68% without radiation, an additional 9 to 11% with radiation; at 50°C, 70 to 80% without radiation, an additional 5 to 10% under radiation. At this treatment level (20 ppm), the Houston Black clay retained more methyl parathion than the other two soils.

The soils treated at 1,000 ppm were analyzed qualitatively for breakdown products, but none were found in the methyl parathion series.

Nayshteyn et al. (1973)[1/] studied the stability and decomposition of methyl parathion and several other pesticides in artificially acidified and alkalinized soils with pH ranges of 3 to 4.6 and 8.7 to 9.6. Methyl parathion was applied at 2 and 200 mg/kg at a soil temperature of 18 to 20°C. Methyl parathion was more stable in the acidic soils, and it was generally more stable than two other organic phosphates studied (not including parathion). The authors report that the rate of decomposition of all three organic phosphate insecticides was comparable in native and in sterile soils. They concluded that the role of soil microorganisms in the degradation of methyl parathion (and of the other two organophosphates) is of secondary importance compared to chemical hydrolysis.

King and McCarty (1968)[2/] developed a chromotagraphic model for predicting pesticide migration in soils. For several insecticides including methyl parathion, theoretical elution curves based on chromotagraphic theory were developed and compared with experimental degradation and leaching data. Four soil types (Hugo, Elkhorn, Sweeney, and Tierra) and different column lengths and pesticide application rates were employed.

Methyl parathion was applied to the four soil types at application rates ranging from 1.0 to 50.0 lb AI/acre. Its half-life ranged from 3 to 11 days. In the Hugo and Elkhorn soils, the application rate did not appreciably affect the half-life. In the Sweeney and Tierra soils, the half-life at 1.0 lb AI/acre was 3 and 5 days, respectively; at 10 lb AI/acre, it was 11 and 8 days, respectively. Parathion was also included in this test series. Its half-life under the same conditions was generally two to four times longer than that of methyl parathion.

[1/] Nayshteyn, S. Y., V. A. Zhulinskaya, and Y. M. Yurovskaya, "The Stability of Certain Phosphororganic Pesticides in the Soil," Gig. Sanit., 38(7):42-45 (1973).

[2/] King, P., and P. L. McCarty, "A Chromatographic Model for Predicting Pesticide Migration in Soils," Soil Sci., 106(4):248-261 (1968).

Field and Combined Field-Laboratory Studies - Lichtenstein and Schulz (1964)[1] applied methyl parathion at 5 lb/acre to Carrington silt loam field plots. Residue levels of methyl parathion of approximately 0.1 ppm (3.1% of the applied dosage) were reached under field conditions within 30 days after the insecticidal application to the soil (90 days in the case of methyl parathion).

Under laboratory conditions (30°C), 95% of an applied methyl parathion dose (200 ppm) was lost within 12 days after application to a loam soil (only 30% of a comparable parathion dose was lost under the same conditions).

Baida (1970)[2] investigated the persistence of methyl parathion and other organic phosphate pesticides in the soil in irrigated field plots at the experimental station of the Kazak Institute of Plant Protection, USSR. A cabbage crop was treated four to five times during the growing season with the insecticides and irrigated six to eight times. Methyl parathion at the rate of 56 lb AI/acre of a 2.5% dust was applied twice, once in July and once in August. Soil samples were taken from the 0 to 4 in. and the 4 to 8 in. soil horizons 15, 30 and 60 days after the last treatment. The results showed that the organophosphorus pesticides disappeared rapidly from the soil which was high in organic matter content. Methyl parathion was still detectable 2 weeks after the second treatment of the cabbage, but residues had declined to nondetectable levels by 4 weeks. Leaching to lower soil horizons was insignificant with all insecticides tested. The author concludes that the rapid disappearance of methyl parathion and the other organic phosphates prevented their accumulation and contamination of the soil.

Monitoring Studies - Stevens et al. (1970)[3] reported on a pilot study conducted nationwide at 51 locations in 1965, 1966, and 1967 to determine pesticide residue levels in soil. Samples were collected from 17 areas in which pesticides were used regularly, 16 areas with a record of at least one pesticide application, and 18 areas with no history of pesticide use. This study was obviously aimed primarily at chlorinated hydrocarbon pesticides; only those organophosphates that were amenable to chlorinated pesticide clean-up methods were detected, and no concerted efforts were made to quantitate metabolites or oxygen analogs of the organophosphates. Pesticide use records indicated that methyl parathion had been used at a number of the sites sampled, but the report does not include any single detection of methyl parathion.

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[1] Lichtenstein, E. P., and K. R. Schulz, "The Effects of Moisture and Microorganisms on the Persistence and Metabolism of Some Organophosphorus Insecticides in Soils, with Special Emphasis on Parathion," J. Econ. Entomol., 57:618-627 (1964).

[2] Baida, T. A., "Soil Pollution by Organophosphorus Pesticides," Zdravookhr. Kazakstana, 30(7):72 (1970).

[3] Stevens, L. J., C. W. Collier, and Donald W. Woodham, "Monitoring Pesticides in Soils From Areas of Regular, Limited, and No Pesticide Use," Pest. Monit. J., 4(3):145-164 (1970).

In the National Soils Monitoring Program for Pesticides, 1,729 samples of cropland soils from 43 states were collected in 1969 (Wiersma et al., 1972[1]). Of these, 66 samples were analyzed for organic phosphate residues, but not a single detection of methyl parathion was reported. In the same program in 1969, 199 samples of noncropland soil were also obtained, but none of these were analyzed for organophosphate residues.

In the National Soils Monitoring Program for Pesticides in 1970 (Crockett et al., 1970[2]), soil and crop samples were collected from 1,506 cropland sites in 35 states. Pesticide use records indicated that methyl parathion had been used at 44 of 1,346 sites sampled, that is 3.27% of all sites. The mean application rate of methyl parathion was 4.16 lb AI/acre. No analyses of soil samples for methyl parathion residues are reported. Samples of alfalfa, field corn kernels, cotton stalks and green bolls, grass hay, field corn stalks, cotton seeds, mixed hay, and soybeans (beans) were analyzed for organophosphate residues. Residues of methyl parathion were found in 9 of 18 samples of cotton stalks and green bolls, ranging from 0.13 to 6.20 ppm, mean 0.58 ppm; and in 7 of 37 samples of cotton seed, ranging from 0.01 to 0.08 ppm, mean 0.01 ppm. No residues of methyl parathion were detected in any of the other commodities analyzed.

Wiersma et al. (1972b)[3] monitored pesticide residues in commercially grown onions and in the soil on which these onions were grown in 1969. A total of 76 sites in 10 major onion-producing states were sampled. According to pesticide use records, methyl parathion was not used at all in any of the onion fields sampled. However, methyl parathion residues were found in 11.8% of the soil samples, ranging from 0.09 to 1.90 ppm, average 0.08 ppm. No residues of methyl parathion (or of any of the other pesticides) were detected in onions. The origin of the methyl parathion residues in the soil samples where it was detected is not clear.

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[1] Wiersma, G. B., H. Tai, and P. F. Sand, "Pesticide Residue Levels in Soils, FY 1969 - National Soils Monitoring Program," Pest. Monit. J., 6(3):194-228 (1972).

[2] Crockett, A. B., G. B. Wiersma, H. Tai, W. G. Mitchell and P. J. Sand, "National Soils Monitoring Program for Pesticide Residues, FY 1970," U.S. Environmental Protection Agency, Technical Services Division, unpublished manuscript (1970).

[3] Wiersma, G. B., W. B. Mitchell, and C. L. Stanford, "Pesticide Residues in Onions and Soil - 1969," Pest. Monit. J., 5(4):345-347 (1972).

There are limitations in National Soils Monitoring Program data. No information is provided on the relationships between time of pesticide application, time of sampling, and time of processing and analysis of the samples. No data is available on the effects of shipping and storage of the samples on the methyl parathion residues that may have been present at the time of sampling.

The California Department of Water Resources (1969, 1970)[1-2] reported pesticide concentrations determined in surface and subsurface drain effluents in the San Joaquin Valley. In 1969, 14 samples of surface drain effluents were analysed for organophosphates. No methyl parathion was found in any of these samples. Eight samples contained "unknown" organophosphate residues that were not further identified. No methyl parathion residues were identified in 41 samples of subsurface drain effluents analysed for organophosphates in the same year (1969). Organic phosphate "unknowns" were found in 19 of these 41 samples, but no further identification was made.

In 1970, 18 samples of surface drain effluents were analyzed for organophosphate compounds. Methyl parathion was positively identified in three of these, at concentrations ranging from 10 to 190 ppt (parts per trillion), averaging 13 ppt in all samples analyzed, 72 ppt in the positive samples. In the same year (1970), 60 samples of subsurface drain effluents were analyzed for organophosphates. Methyl parathion was detected in eight of these, at concentrations ranging from 10 to 170 ppt, averaging 29 ppt in all samples analyzed, 76 ppt in the positive samples.

These data show that only very small quantities of methyl parathion (and of other organophosphate insecticides) were present in these effluents.

1/ California Department of Water Resources, San Joaquin Valley Drainage Monitoring Program, 1969 Summary, Sacramento, California (1969). (In: Li and Fleck, 1972.)

2/ California Department of Water Resources, San Joaquin Valley Drainage Monitoring Program, 1970 Summary, Sacramento, California (1970). (In: Li and Fleck, 1972.)

Summary - The data on the residues and fate of methyl parathion in the soil reviewed in this section show that methyl parathion is generally several times less persistent in the soil than parathion. Methyl parathion soil residues resulting from crop protection uses at recommended dosage levels appear to be degraded in the soil very quickly.

As with parathion, the soil degradation of methyl parathion is probably temperature dependent. Data presented in next subsection of this scientific review on "Use patterns of methyl parathion in the United States," show that only very small quantities of methyl parathion are used in the Northeastern, North Central and Northwestern states of the U.S. An estimated 98% of the total quantity of methyl parathion used in the U.S. in 1972 was used in the Southeastern, South Central and Southwestern states where higher temperatures would promote rapid degradation of methyl parathion in the soil.

Soil monitoring data currently available are totally inadequate to show whether or not these theoretical expectations are true. Likewise, no data are available on the fate of the initial degradation products of methyl parathion, especially p-nitrophenol and amino-methyl parathion, or on the effects of these breakdown products on organisms other than mammals and insects.

Residues in Water

Laboratory and Field Studies - Lichtenstein et al. (1966)[1] studied the persistence of methyl parathion and several other insecticides in lake water and soil water over a 1-year period. Lake water was collected from the surface and near the shore line of Lake Mendota, Madison, Wisconsin, and soil water was obtained by percolating 3,000 ml of distilled water through a 45.0 by 7.5 cm column of Carrington silt loam untreated with insecticides. Volumes of 1,200 ml of both types of water were treated with methyl parathion at the rate of 1 ppm, using 10 ml of acetone containing 1.2 mg of the insecticide. The water samples were then kept at 28°C in darkness. They were bioassayed for toxicity to mosquito larvae, and subjected to chemical analysis at different intervals.

Methyl parathion in lake water produced 10% mortality of mosquito larvae after 3 months, 0% after 4 months. In the soil water, methyl parathion produced 100% mosquito larvae mortality after 0.5 months, but was nontoxic to the mosquito larvae after 1 month. By gas chromatographic analysis, no methyl parathion residues were detected in either water after 7 months. By bioassay as well as by chemical analysis, methyl parathion was considerably less persistent in this test than parathion. Methyl parathion (as well as parathion) persisted longer in lake water than in soil water.

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[1] Lichtenstein, E. P., K. R. Schulz, R. F. Skrentny, and Y. Tsukano, "Toxicity and Fate of Insecticide Residues in Water," Arch. Environ. Health, 12:199-212 (1966).

Eichelberger and Lichtenberg (1971)[1] investigated the persistence of methyl parathion and a number of other common pesticides in raw river water over an 8-week period. Aliquots of 10 µg/liter of methyl parathion from a freshly prepared 0.1% solution in acetone were injected into samples of raw water from the Little Miami River, a relatively small stream receiving domestic and industrial wastes and farm runoff. The spiked raw river water was kept in the laboratory in closed glass containers at room temperature, exposed to natural and artificial light. Only 80% of the initial concentration of methyl parathion remained after 1 hr; 25% after 1 week; 10% after 2 weeks, 0% after 4 weeks. When methyl parathion was added to distilled water in the same manner, it remained completly stable for an observation period of 3 weeks.

With the use of thin layer chromatography, it was determined that methyl parathion was hydrolyzed to _p_-nitrophenol and dimethylthiophosphoric acid.

Under the same experimental conditions, parathion was about two to three times more persistent than methyl parathion in the river water.

Hazeltine (1962)[2] reported that in lake water (Clear Lake, California), methyl parathion degraded rapidly. After application of rates effective for the control of the Clear Lake gnat, _Chaoborus astictopus_, 2.5 and 3.3 ppb, 50% degradation occurred in less than 2 days.

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[1] Eichelberger, J. W., and J. J. Lichtenberg, "Persistence of Pesticides in River Water," _Environ. Sci. Technol._, 5(6):541-544 (1971).

[2] Hazeltine, W. E., "Safety of Wildlife is Important to Planners of Gnat - Control Program," _Agr. Chem._, pp. 12-14, 76 (1962).

Residues in Air

There is little data available on the origin, presence and persistence of methyl parathion residues in air.

Stanley et al. (1971)[1] conducted a pilot study to establish a system for measuring the extent of atmospheric contamination of the air by pesticides in nine localities throughout the United States. Samples were analyzed for 19 pesticides and metabolites, including methyl parathion. Methyl parathion was found at three of the nine sampling locations, i.e., Dothan, Alabama (rural), Orlando, Florida (rural), and Stoneville, Mississippi (rural). At Dothan, nine of 90 samples contained detectable amounts of methyl parathion, the maximum level found was 29.6 ng/m^3 of air. At Orlando, three of 99 samples contained methyl parathion; the maximum level was 5.4 ng/m^3. At Stoneville, 40 of 98 samples contained methyl parathion; the maximum level was 129 ng/m^3. Higher pesticide levels were usually associated with pesticide spraying. The authors point out that the levels of pesticide found in the ambient air were almost entirely far below levels that might add significantly to the total human intake of pesticides.

Tessari and Spencer (1971)[2] analyzed air samples from human environments in the Greeley, Colorado, area for pesticide residues. Nylon chiffon cloth screens were exposed to the indoor and outdoor air at the homes of 12 men (farmers and pesticide formulators) occupationally exposed to pesticides. Over a period of 1 year, the screens were exposed to the atmosphere in these environments for 5 days each month, after which residues were extracted from them with suitable solvents and determined by gas chromatographic analysis.

Methyl parathion was found in 13 of 52 indoor air samples from formulators' households. In the positive samples, methyl parathion residues ranged from 0.04 to 9.40 μg/m^2 of filter; the mean was 1.04 μg/m^2. In samples of outdoor air near formulators' households, methyl parathion was found in three of 53 samples. In the positive samples, residues ranged from 0.15 to 0.71 μg/m^2; the mean was 0.35 μg/m^2. No methyl parathion residues were found in the indoor or outdoor air near farmers' households.

Parathion which was also included in this investigation was found in a much higher percentage of the samples tested, generally at considerably higher concentrations.

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[1] Stanley, C. W., J. E. Barney, II, M. R. Helton, and A. R. Yobs, "Measurement of Atmospheric Levels of Pesticides," Environ. Sci. Technol., 5(5):430-435 (1971).

[2] Tessari, J. D., and D. L. Spencer, "Air Sampling for Pesticides in the Human Environment," J. Assoc. Offic. Anal. Chem., 54(6):1376-1382 (1971).

Adair et al. (1971)[1] studied the drift of methyl parathion following aerial application of an emulsifiable concentrate formulation containing 4 lb AI/gal applied either undiluted (ULV), or diluted in water at a volume of 2 gal/acre (LV). Both sprays were applied at the rate of 1.0 lb AI/acre from an airplane flying at a height of 5 ft at 80 mph. Each treatment was repeated three times. Insecticidal deposits were sampled in the swath and downwind from it at various intervals down to 1/2 mile with filter paper sheets and oil-sensitive cards. Aerial drift was studied in air samples taken at several locations downwind of the swath with cascade impactors.

The ULV-applied methyl parathion spread over a wider swath and was deposited on the ground sample sheets in higher concentrations downwind from the swath than the LV applications. The cascade impactor studies showed that the amount of airborne drift downwind at the 5 ft sampling height was much greater from the ULV application than from the LV applications at the 100 and 330 ft sites, and slightly greater at the 660- to 2,640-ft sites. For all applications studied, the total amount of methyl parathion recovered in the target area and within 2,640 ft downwind from it represented about 40 to 50% of the amount applied. These data show that a large share of the material applied in this manner may become quickly airborne and possibly move permanently into the atmosphere with very little material falling to the ground downwind.

The reports reviewed indicate that methyl parathion residues may be present in the atmosphere. The material balance studies by Adair et al. indicate that at least under the conditions of their study, about one-half of the quantity of methyl parathion applied by air did not impinge in the target area or within 2,640 ft downwind from it; apparently the methyl parathion met an unknown fate and destination.

Residues in Nontarget Plants

In accordance with the work plan for this project, residues and metabolism of methyl parathion in food and feed commodities are not covered in this subsection, but the subsection on chemistry.

With the exception of a report by Applegate (1970)[2] there were no reports found on methyl parathion residues in nontarget plants. Applegate sampled the leaves of leatherstem (*Jatropha dioica*), a wild plant in the Big Bend National Park in Texas. Residues of methyl parathion were found in four out of nine samples of leatherstem leaves analyzed, ranging from 0.01 to 0.09 ppm. These residues are considerably below those encountered on target plants following insecticidal applications of parathion. However, they were found in plants growing in a park not subject to insecticide treatments.

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[1] Adair, H. M., F. A. Harris, M. V. Kennedy, M. L. Laster, and E. D. Threadgill, "Drift of Methyl Parathion Aerially Applied Low Volume and Ultra Low Volume," *J. Econ. Entomol.*, 64(3):718-721 (1971).

[2] Applegate, H. G., "Insecticides in the Big Bend National Park," *Pest. Monit. J.*, 4(1):2-7 (1970).

In a report on insecticide concentrations in wildlife at Presidio, Texas, Culley and Applegate (1967) expressed the opinion that methyl parathion could accumulate in leatherstem because leaves of this perennial plant had higher methyl parathion concentrations in June than did leaves of cotton, an annual plant.

Bioaccumulation, Biomagnification

There was no data found specifically on the possible bioaccumulation of methyl parathion. The physical, chemical, and biological properties of methyl parathion make it unlikely that biomagnification in food chains or food webs occurs, and there is no evidence that it does. Methyl parathion is neither lipophilic or chemically stable, the two properties whose combination produces the biomagnification phenomenon described for chlorinated hydrocarbon insecticides and other chemicals. However, Butler 1/ has found 59 ppb methyl parathion in spotted seatrout, Cynoscion nebulosus, ovaries collected near Arroyo City, Texas. Although measurements of residues of the parent compound are necessary and of interest environmentally, the insidious effects are probably the greatest threat environmentally. It must be noted that organophosphates inhibit brain cholinesterase in fishes at concentrations much lower than the short term LC_{50}.

Environmental Transport Mechanisms

Freed et al. (unpublished data quoted from von Rümker and Horay, 1972 2/) determined the propensity of methyl parathion for volatilization and leaching under simulated field conditions for loam soils at 25°C at an annual rainfall of 59 in. (150 cm). Volatilization of pesticides under these conditions, i.e., from a porous, sorptive medium (loam soil) in a nonequilibrium situation, is different from volatilization from an inert surface or from the chemical's own surface. Therefore, the environmental volatilization index assigned to pesticides studied in this manner may or may not parallel a chemical's vapor pressure.

By this method, methyl parathion rated a volatilization index of three, indicating an estimated median vapor loss from treated areas of

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1/ Butler, P.A., Data from U.S. Environmental Protection Agency, National Estuarine Monitoring Program. (Unpublished).

2/ von Rümker, R., and F. Horay, "Pesticide Manual," Department of State, Agency for International Development, 1:173, 268 (1972).

4.45 lb/acre/year. This index number indicates a relatively high potential for volatilization of methyl parathion from treated soils, compared to many other pesticides.

Leaching index numbers for pesticides indicate the approximate distance that the chemical would move through the standardized loam soil profile under an annual rainfall of 59 in. (150 cm). Under these conditions, methyl parathion rated a leaching index of two, indicating movement of 4 to 8 in.

These volatilization and leaching index numbers for methyl parathion, along with the laboratory and field observations reviewed above, indicate that volatilization appears to be an important environmental transport mechanism for this insecticide. Surface runoff in water or adsorbed on solids may also occur, but methyl parathion is relatively unstable in the presence of soil or field water. Leaching of methyl parathion through soil profiles does not occur readily, and it is not likely that contamination of subsoil or groundwater could occur from normal use because of the relatively low leaching propensity, and the short persistence of methyl parathion in the soil.

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SUBPART II. D. PRODUCTION AND USE

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This section contains data on the production and uses of methyl parathion. It is organized according to three subject areas: registered uses, production and domestic supply, and use patterns. The section summarizes rather than interprets scientific data reviewed.

Registered Uses of Methyl Parathion

Federally Registered Uses - Methyl parathion has a broad spectrum of effectiveness against insects. Efficacy claims also include some species of mites. Methyl parathion is registered and recommended in the United States for use on a large number of crops, including important field, forage and vegetable crops.

Tolerances for residues of methyl parathion have not been established, but all residue tolerances established for its ethyl homolog, parathion, have been declared applicable to methyl parathion.

All registered uses of methyl parathion by crops, target pests, dosage rates, formulations, type of use, established tolerances, and use, timing, and pre-harvest interval limitations are summarized in the EPA Compendium of Registered Pesticides, III-D-41.1 through 41.40. It is interesting to note that this 40-page section on methyl parathion is only one-fourth as long as the comparable section on parathion, demonstrating the fact that methyl parathion is registered and recommended for a much smaller spectrum of crop protection and related uses than its ethyl homolog.

The registered uses of methyl parathion are illustrated in the following tables:

1. Table 17. Methyl parathion -- Summary of registered uses of crops, application rates, and rate and time restrictions.
2. Table 18. Pest -- Insects and mites against which methyl parathion is recommended (in alphabetical order by common names).
3. Tables 19 and 20. Registered uses of one of the common formulations of methyl parathion, i.e., emulsifiable liquid containing 4 lb of AI per gallon, by crops; insects and other pests controlled on each crop; recommended dosage rates; and general specific directions for, and limitations of use.

Methyl parathion is also available to users in the form of emulsifiable liquids containing 2.0, 3.2, and 4.25 lb of AI per gallons; in the form of a 2% liquid, and in the form of 70 and 80% technical solutions. A few formulators offer methyl parathion dusts. There are no methyl parathion pressurized sprays or granular formulations on the market.

In addition to these formulations containing methyl parathion as the only active ingredient, there are several formulations combining it with other insecticides. For instance, a formulation containing 6 lb of parathion and 3 lb of methyl parathion AI per gallon is offered by several major producers.

For most registered uses of methyl parathion, the rate of active ingredient recommended per acre or per volume of spray for a given use is the same, regardless of the type of formulation in which the product is applied.

State Regulations - In many of the states that currently regulate the use of pesticides, methyl parathion is subject to use restrictions. For instance, in California, methyl parathion is one of 42 pesticides that have been designated as "injurious or restricted materials." The use of these pesticides is subject to special restrictions under regulations administered by the California State Department of Agriculture. A permit from the County Agricultural Commissioner must be obtained for the use of methyl parathion. The product may not be applied in any location where damage, illness or injury may result (from direct application, drift, or residue) to persons, other crops, or animals (including honeybees) other than the pest(s) which the application is intended to destroy.

Before methyl parathion is applied, warning must be given to all persons known to be on the property. After any formulation containing methyl parathion has been applied at a rate greater than 1 lb of active ingredient per acre, adequate warning must be given to persons who enter the treated property at the point or points of normal entry. The warning notice must be readable at a distance of 25 ft.

Table 17. METHYL PARATHION - SUMMARY OF REGISTERED USES BY CROPS, APPLICATION RATES AND RATE AND TIME RESTRICTIONS

Target crops	Rate per application (lb/AI)	Maximum permissible AI rate (lb/acre)	Minimum time, last treatment to harvest (days)
Agricultural crops			
Alfalfa	0.23 - 1.25/acre		15 day 0.23 thru 1.0/acre
Alfalfa (seed)	0.23 - 1.25/acre		15 day 0.23 thru 1.0/acre
			20 day > 1.0 thru 1.25/acre
Almonds 1/			
Apples	0.12 - 1.0/100 gal	6.0	14 day thru 6.0 lb/acre
Apricots	0.12 - 0.25/100 gal	2.5	14 day thru 2.5 lb/acre
Artichokes	0.5 - 1.0/acre		7 day 0.5 thru 1.0/acre
Barley	0.12 - 0.75/acre		0 day 0.12 thru 0.25/acre
			15 day > 0.25 thru 0.75/acre
Beans (dry, green and lima			15 day 0.5 thru 1.5/acre
			15 day 0.5
			21 day > 0.50 thru 1.5 acre
Beets	0.46 - 1.0/acre		15 day 0.46 thru 1.0/acre
			21 day 0.46 thru 1.0/acre 2/
Black eyed peas 1/			
Broccoli	0.25 - 1.5/acre		7 day 0.25 thru 0.5/acre
			21 day > 0.50 thru 1.5/acre
Brussels sprouts	0.25 - 1.5/acre		7 day 0.25 thru 0.5/acre
			21 day > 0.50 thru 1.5/acre
Cabbage	0.25 - 1.5/acre		10 day 0.25 thru 0.5/acre
			21 day > 0.5 thru 1.5/acre
Carrots	0.46 - 1.0/acre		15 day 0.46 thru 1.0/acre
Cauliflower	0.25 - 1.5/acre		7 day 0.25 thru 0.5/acre
			21 day > 0.50 thru 1.5/acre
Celery	0.46 - 1.0/acre		15 day 0.46 thru 1.0/acre

Table 17. (Continued)

Target crops	Rate per application (lb/AI)	Maximum permissible AI rate (lb/acre)	Minimum time, last treatment to harvest (days)
Agricultural crops (continued)			
Cherries	0.125 - 25/100 gal	2.5	14 day thru 2.5 lb/acre
Clover	0.25 - 1.25/acre		15 day 0.25 thru 1.0/acre 20 day >1.0 thru 1.25/acre
Collards	0.5 - 1.5/acre		10 day 0.5/acre 21 day >0.5 thru 1.5/acre
Corn	0.25/acre		12 day 0.25/acre
Cotton	0.12 - 3.0/acre		7 day 0.12 thru 3.0/acre
Cucumbers	0.25/acre		15 day 0.25/acre
Eggplant[1]			
Gooseberries	0.12 - 0.25/acre		15 day 0.12 thru 0.25/acre
Grapes	0.25 - 1.0/100 gal	0.75	14 day thru 0.75 lb/acre
Grass (hay and pastures	0.75/acre		15 day 0.75/acre
Hops	0.5 - 1.0/acre		15 day 0.5 thru 1.0/acre
Kale	0.25 - 1.5/acre		10 day 0.25 thru 0.5/acre 21 day >0.5 thru 1.5/acre
Kohlrabi	0.25 - 1.5/acre		7 day 0.25 thru 0.5/acre 21 day >0.5 thru 1.5/acre
Lettuce	0.46 - 1.0/acre		21 day 0.46 thru 1.0/acre
Melons[1]			7 day thru 2.0/acre
Mustard greens	0.25 - 1.5/acre		10 day 0.25 thru 0.5/acre 21 day >0.5 thru 1.5/acre
Nectarines[1]			
Oats	0.12 - 0.75/acre		0 day thru 0.25/acre 15 day >0.25 thru 0.75/acre

Table 17. (Continued)

Target crops	Rate per application (lb/AI)	Maximum permissible AI rate (lb/acre)	Minimum time, last treatment to harvest (days)
Agricultural crops (continued)			
Onions	0.25 - 0.87/acre		15 day thru 0.87/acre
Peaches	0.12 - 1.0/100 gal	4.0	14 day thru 4.0/acre
Peanuts	0.375/acre		15 day thru 0.375/acre
Pears	0.12 - 0.5/100 gal	3.0	14 day thru 3.0/acre
Peas	0.46 - 1.0/acre		10 day 0.46 thru 0.5/acre 15 day >0.5 thru 1.0/acre
Peppers	0.46 - 1.0/acre		15 day thru 1.0/acre
Plums, prunes	0.12 - 1.0/100 gal	4.0	14 day thru 4.0/acre
Potatoes	0.25 - 1.5/acre		5 day thru 1.5/acre
Pumpkins[1]			
Rice	0.25 - 0.75/acre		10 day thru 0.25/acre 15 day >0.25 thru 0.75/acre
Rutabagas	0.5 - 1.5/acre		7 day thru 0.5/acre 21 day >0.5 thru 1.5/acre
Rye	0.12 - 0.75/acre		0 day 0.12 thru 0.25/acre 15 day >0.25 thru 0.75/acre
Safflower[3]	0.5/acre		
Sorghum	0.5 - 1.0/acre		21 day 0.5 thru 1.0/acre
Soybeans	0.25 - 1.0/acre		20 day 0.25 thru 1.0/acre
Spinach	0.46 - 1.0/acre		14 day 0.46 thru 0.5/acre 21 day >0.5 thru 1.0/acre
Squash[1]			
Strawberries	0.5 - 0.75/acre		14 day 0.5 thru 0.75/acre
Sugar beets	0.25 - 0.375/acre		20 day 0.25 thru 0.375/acre

Table 17. (Continued)

Target crops	Rate per application (lb/AI)	Maximum permissible AI rate (lb/acre)	Minimum time, last treatment to harvest (days)
Agricultural crops (continued)			
Sunflowers	1.0/acre		30 day thru 1.0/acre
Sweet potatoes	0.75/acre		15 day thru 0.75/acre
Tobacco	0.25 - 0.5/acre		15 day 0.188 thru 0.5/acre
Tomatoes	0.12 - 1.5/acre		10 day 0.12 thru 0.5/acre 15 day >0.5 thru 1.5/acre
Turnips	0.25 - 0.80/acre		7 day thru 0.25/acre 15 day >0.25 thru 0.8/acre
Vetch	0.25 - 1.25/acre		15 day 0.25 thru 1.0/acre 20 day >1.0 thru 1.25/acre
Wheat	0.12 - 0.75/acre		0 day thru 0.25/acre 15 day >0.25 thru 0.75/acre
Ornamentals			
Christmas tree plantations (pine)	0.1/acre		None
Forest, nonagricultural and wastelands			
Pine forests	1.0/acre		None

1/ Use only in formulations with parathion.
2/ 21-day preharvest interval thru 1.016/acre if tops are to be fed to livestock.
3/ Do not apply after flowering thru 0.5/acre.
Compiled from the EPA Compendium of Registered Pesticides, Vol. III.

Table 18. PEST INSECTS AND MITES AGAINST WHICH METHYL PARATHION IS RECOMMENDED (IN ALPHABETICAL ORDER BY COMMON NAMES)

Common name	Scientific name
Alfalfa caterpillar	Colias eurytheme
Alfalfa seed chalcid	Bruchophagus roddi
Alfalfa weevil	Hypera postica
*Aphids	Family Aphididae
Armyworm	Pseudaletia unpuncta
Artichoke plume moth	Platyptilia carduidactyla
Black grass bugs	Family Miridue
Bean leaf beetle	Cerotoma trifurcata
Beet armyworm	Spodoptera exigue
Blister beetle	Family Meloidae
Boll weevil	Anthonomus grandis
Bollworms	Heliothus spp.
Cabbage looper	Trichoplusia ni
Chinch bug	Blissus leucopterus
Clover leaf weevil	Hypera punctata
Clover seed chalcid	Bruchophagus platypera
Coding moth	Laspeyresia pomonella
Corn earworm	Heliothis zea
Corn rootworm	Diabrotica spp.
Cotton leafperforator	Bucculatrix thurberiella
Cotton leaf worm	Alabama argillacea
Cowpea curculio	Chalcodermus aeneus
*Cutworms	Family Noctuidae
European pine shoot moth	Rhyacionia buoliana
Egyptian alfalfa weevil	Hypera brunneipennis
Fall armyworm	Spodoptera frugiperda
False chinch bug	Family Lygaeidae
Flea beetles	Family Chrysomelidae
Fleahoppers	Family Miridae
Grape leaffolder	Demsia funeralis
Grass bugs	Family Miridae
Grasshoppers	Family Acrididae
Green cloverworm	Plathyaena scabra
Green June beetle	Cotinis nitida
Imported cabbage worm	Pieris rapae
Leafhoppers	Family Cicadellidae
Leaf miners	Class Insecta
*Leafrollers	Class Insecta
Lygus bugs	Lygus sp.
Mexican bean beetle	Epilachna varivestis
Mites	Order Acarina
Mosquitoes	Family Culicidae
Nantucket pine tip moth	Rhyacionia frustrana
Oriental fruit moth	Grapholitha molesta
Peachtree borer	Sanninoidea exitiosa

Table 18. (Continued)

Common name	Scientific name
Plant bugs	Family Miridae
Plum curculio	Conotrachelus nenuphar
Potato psyllid	Paratrioza cockerelli
Rice leafminer (Calif. only)	Hydrellia griseola
Saltmarsh caterpillar	Estigmene acrea
*Scales	Family Coccoidae
Seedcorn maggot	Hylemya platura
Sorghum midge	Contarinia sorghicola
Stink bugs	Family Pentatomidae
Sunflower moth	Homoeosoma electellum
Tadpole shrimp (Calif. only)	Order Notostraca
Threecolored alfalfa hopper	Spissistilus festinus
*Thrips	Order Thysanoptera
Velvetbean caterpillar	Anticarsia gemmatalis
Vetch bruchid	Bruchus brachialis
*Webworms	Order Lipdoptera
Yellow striped armyworm	Spodoptera ornithogalli

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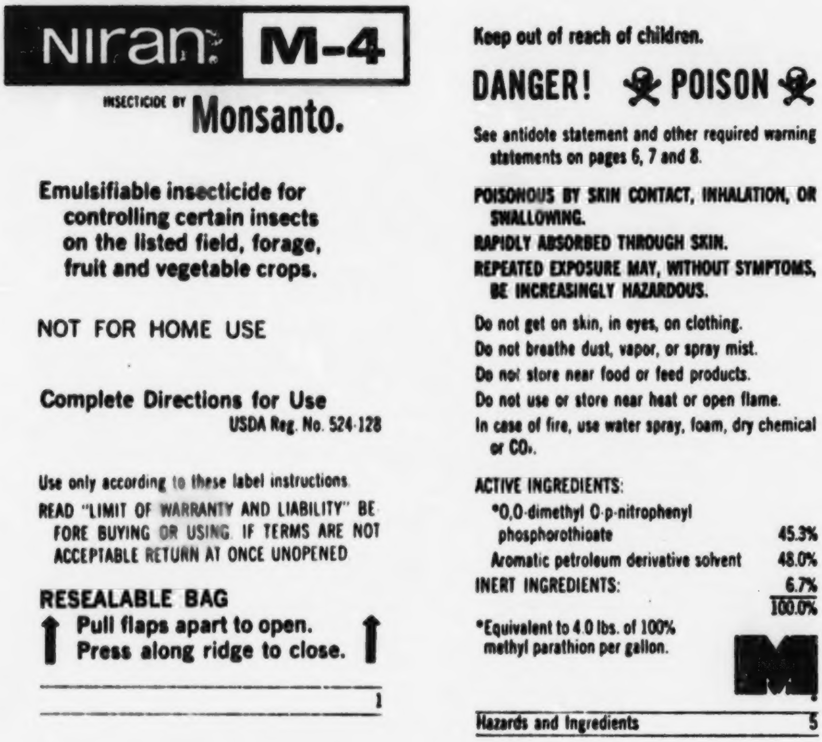
* For specific pests see EPA Compendium of Registered Pesticides, Volume III.

Table 19. REGISTERED USES OF METHYL PARATHION EMULSIFIABLE LIQUID (4 LB ACTIVE INGREDIENT PER GALLON) - CROPS AND OTHER USES, PESTS, DOSAGE RATES AND USE LIMITATIONS[a/]



Niran® M-4

INSECTICIDE BY **Monsanto.**

Emulsifiable insecticide for controlling certain insects on the listed field, forage, fruit and vegetable crops.

NOT FOR HOME USE

Complete Directions for Use

USDA Reg. No. 524-128

Use only according to these label instructions.

READ "LIMIT OF WARRANTY AND LIABILITY" BEFORE BUYING OR USING. IF TERMS ARE NOT ACCEPTABLE RETURN AT ONCE UNOPENED

RESEALABLE BAG

↑ **Pull flaps apart to open. Press along ridge to close.** ↑

1

Keep out of reach of children.

DANGER! ☠ POISON ☠

See antidote statement and other required warning statements on pages 6, 7 and 8.

POISONOUS BY SKIN CONTACT, INHALATION, OR SWALLOWING.

RAPIDLY ABSORBED THROUGH SKIN.

REPEATED EXPOSURE MAY, WITHOUT SYMPTOMS, BE INCREASINGLY HAZARDOUS.

Do not get on skin, in eyes, on clothing.

Do not breathe dust, vapor, or spray mist.

Do not store near food or feed products.

Do not use or store near heat or open flame.

In case of fire, use water spray, foam, dry chemical or CO_2.

ACTIVE INGREDIENTS:	
*O,O-dimethyl O-p-nitrophenyl phosphorothioate	45.3%
Aromatic petroleum derivative solvent	48.0%
INERT INGREDIENTS:	6.7%
	100.0%

*Equivalent to 4.0 lbs. of 100% methyl parathion per gallon.

Hazards and Ingredients 5

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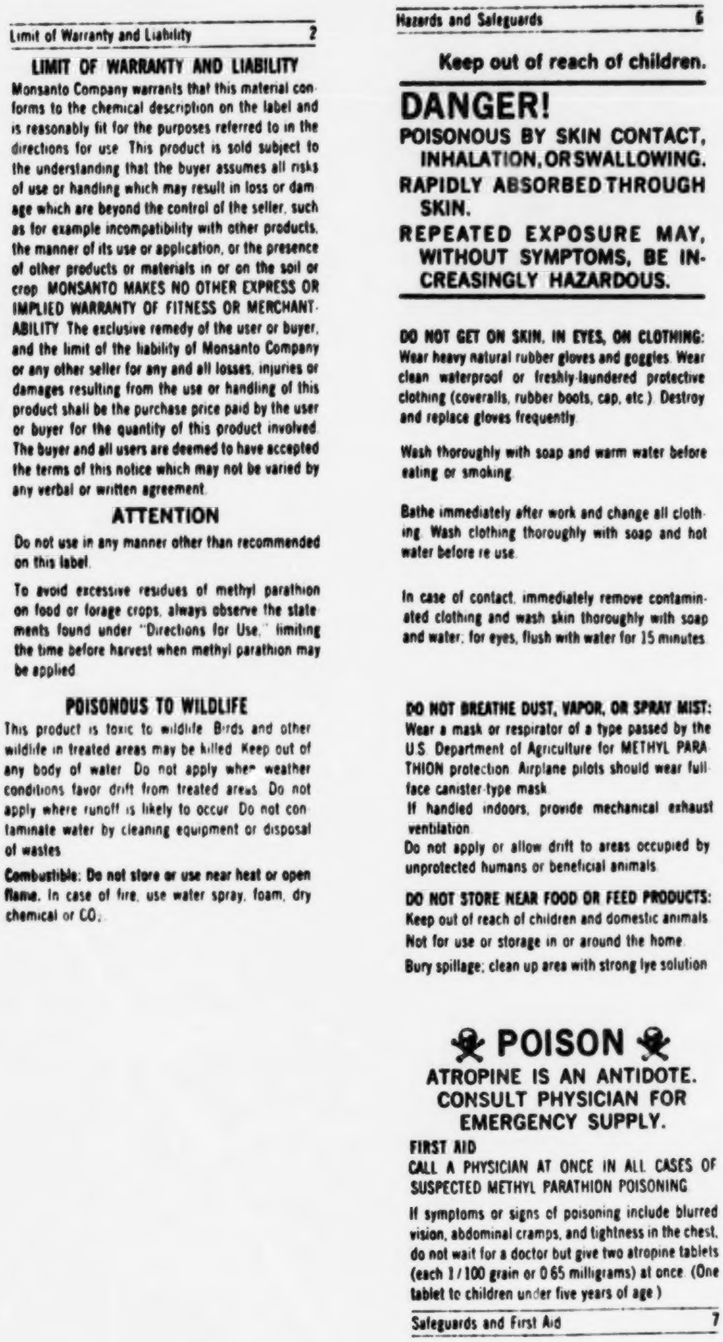
a/ Sample label of Monsanto Company, St. Louis, Mo.
EPA Registration No. 524-128.
This formulation is not currently marketed by Monsanto, but the label is being made available to Monsanto's formulator customers for methyl parathion technical (Personal Communication, May 10, 1974).

Table 19. (Continued)



Limit of Warranty and Liability 2

LIMIT OF WARRANTY AND LIABILITY

Monsanto Company warrants that this material conforms to the chemical description on the label and is reasonably fit for the purposes referred to in the directions for use This product is sold subject to the understanding that the buyer assumes all risks of use or handling which may result in loss or damage which are beyond the control of the seller, such as for example incompatibility with other products, the manner of its use or application, or the presence of other products or materials in or on the soil or crop MONSANTO MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS OR MERCHANTABILITY The exclusive remedy of the user or buyer, and the limit of the liability of Monsanto Company or any other seller for any and all losses, injuries or damages resulting from the use or handling of this product shall be the purchase price paid by the user or buyer for the quantity of this product involved. The buyer and all users are deemed to have accepted the terms of this notice which may not be varied by any verbal or written agreement.

ATTENTION

Do not use in any manner other than recommended on this label.

To avoid excessive residues of methyl parathion on food or forage crops, always observe the statements found under "Directions for Use," limiting the time before harvest when methyl parathion may be applied

POISONOUS TO WILDLIFE

This product is toxic to wildlife Birds and other wildlife in treated areas may be killed Keep out of any body of water Do not apply when weather conditions favor drift from treated areas Do not apply where runoff is likely to occur Do not contaminate water by cleaning equipment or disposal of wastes

Combustible: Do not store or use near heat or open flame. In case of fire, use water spray, foam, dry chemical or CO.

Hazards and Safeguards 6

Keep out of reach of children.

DANGER!

POISONOUS BY SKIN CONTACT, INHALATION, OR SWALLOWING.

RAPIDLY ABSORBED THROUGH SKIN.

REPEATED EXPOSURE MAY, WITHOUT SYMPTOMS, BE INCREASINGLY HAZARDOUS.

DO NOT GET ON SKIN, IN EYES, ON CLOTHING: Wear heavy natural rubber gloves and goggles. Wear clean waterproof or freshly-laundered protective clothing (coveralls, rubber boots, cap, etc). Destroy and replace gloves frequently

Wash thoroughly with soap and warm water before eating or smoking

Bathe immediately after work and change all clothing. Wash clothing thoroughly with soap and hot water before re use

In case of contact, immediately remove contaminated clothing and wash skin thoroughly with soap and water; for eyes, flush with water for 15 minutes

DO NOT BREATHE DUST, VAPOR, OR SPRAY MIST: Wear a mask or respirator of a type passed by the U.S. Department of Agriculture for METHYL PARATHION protection. Airplane pilots should wear full-face canister-type mask

If handled indoors, provide mechanical exhaust ventilation

Do not apply or allow drift to areas occupied by unprotected humans or beneficial animals

DO NOT STORE NEAR FOOD OR FEED PRODUCTS:

Keep out of reach of children and domestic animals

Not for use or storage in or around the home

Bury spillage; clean up area with strong lye solution

☠ POISON ☠

ATROPINE IS AN ANTIDOTE. CONSULT PHYSICIAN FOR EMERGENCY SUPPLY.

FIRST AID

CALL A PHYSICIAN AT ONCE IN ALL CASES OF SUSPECTED METHYL PARATHION POISONING

If symptoms or signs of poisoning include blurred vision, abdominal cramps, and tightness in the chest, do not wait for a doctor but give two atropine tablets (each 1/100 grain or 0.65 milligrams) at once. (One tablet to children under five years of age)

Safeguards and First Aid 7

Table 19. (Continued)

First Aid and Antidote 8

Move patient immediately from the area where methyl parathion is present.

Remove contaminated clothing and wash the skin clean with plenty of soap and water to remove all traces of methyl parathion. If swallowed, induce vomiting by giving salty or soapy warm water. Have victim lie down and keep quiet.

NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

PHYSICIANS NOTE: This product is a cholinesterase inhibitor. Warning symptoms include weakness, headache, tightness in the chest, blurred vision, non-reactive pin-point pupils, salivation, sweating, nausea, vomiting, diarrhea, and abdominal cramps.

TREATMENT: Large doses of atropine are required. For adults, give 2.0 mg. to 4.0 mg. of atropine, preferably by intravenous injection, at once and repeat every 10 to 15 minutes until pupils dilate. In addition to atropine, if 2-PAM Chloride (pralidoximechloride) is available, administer according to manufacturer's directions. Never give morphine. Clear chest by postural drainage. Artificial respiration or oxygen administration may be necessary. Observe patient continuously 48 hours. Repeated exposure to cholinesterase inhibitors may, without warning, cause prolonged susceptibility to very small doses of any cholinesterase inhibitor. Allow no further exposure until time for cholinesterase regeneration has been allowed as determined by blood tests.

TO PREVENT PERSONAL INJURY AND POSSIBLE FATALITIES:

Keep all persons and animals out of treated areas for 48 hours.

Vacated areas should not be re-entered until drifting insecticide and volatile residues have dissipated.

Because this material is poisonous by skin contact, inhalation or swallowing it should not be used in such a manner or under weather conditions as will permit drift of the spray onto areas not intended to be sprayed.

This product is highly toxic to bees exposed to direct treatment or residues on crops. Protective information may be obtained from your Cooperative Agricultural Extension Service.

DISPOSAL OF EMPTY CONTAINER—Do not re-use this container. Completely empty the contents and bury the unused chemical at least 18 inches deep in an isolated location away from water supplies. Rinse out the inside of the container with water to which has been added detergent and caustic soda. Carefully discard the rinse solution by burying at least 18 inches deep in an isolated area away from water supplies. Puncture and crush empty metal container and bury at least 18 inches deep in a supervised public or private dump.

Prevent Injury and Container Disposal 9

Directions for Use 10

DIRECTIONS FOR USE

Be sure to read the precautionary statements before using!

This product is designed for application after dilution with water and for use by trained operators using airplane or power ground equipment. The hazards and precautions for handling the product in this container are equally applicable to it after dilution with water for spray application. Add the concentrate to the spray tank while filling with water, and mix thoroughly either by means of a tank agitator or pump by-pass. For best results, thoroughly cover all surfaces to be treated with spray. Rates of application given below should not be exceeded. Never apply later than indicated to assure residue levels at harvest are below tolerances established by the Food and Drug Administration.

Consult the State Agricultural Extension Service or Experiment Station for specific recommendations regarding application, dosage and timing of sprays. For application by ground equipment, add the desired amount of concentrate to sufficient water to apply at least 3 gallons of water per acre. For application by aircraft, add the amount of concentrate desired per acre to ½ to 3 gallons of water consistent with crop growth and good coverage. Greater quantities of water may be required to give sufficient coverage of orchard trees.

Table 19. (Continued)

CEREAL

BARLEY, OATS, RYE AND WHEAT—For barley thrips, use ½ to ¾ pint per acre. For aphids, armyworms up to third instar, leafhoppers and winter grain mites, use ½ to 1½ pints per acre. For climbing cutworms use ¾ to 1 pint per acre. For chinch bugs, false chinch bugs and Say's plant bugs, use 1½ pints per acre. For western or brown wheat mites, use 1 pint per acre. Do not use more than ½ pint per acre within 15 days of harvest.

CORN—For control of armyworms up to third instar, climbing cutworms, corn leaf aphids, corn rootworm adults, fall armyworms and stink bugs, use ½ pint per acre. Do not apply within 12 days of harvest.

RICE—For rice stink bugs, use ½ to 1 pint per acre. Do not apply within 15 days of harvest. Shrimp, crabs and crayfish may be killed. Do not apply where these are important resources.

SORGHUM—For corn leaf aphids and mites, use 1 pint per acre. For sorghum midges, use 1 pint to 1 quart per acre, 2 applications, 3 to 5 days apart when approximately 90% of the heads have completely emerged from the boot or not later than start of blooming. Do not apply closer than 21 days before harvest. Leaf injury may occur on some hybrid varieties of sorghum. Spray a few rows a week or so before booting to test effects upon plants.

FIELD AND FORAGE CROPS

ALFALFA AND CLOVER—For control of alfalfa weevil larvae, aphids (including spotted alfalfa aphids) and climbing cutworms, use ½ to 1 pint per acre. For alfalfa caterpillars, alfalfa adult weevils, armyworms up to third instar, clover leaf weevils and webworms, use 1 pint per acre. For Egyptian alfalfa weevils, leafhoppers, Lygus bugs and spider mites, use 1 to 2 pints per acre. Do not treat closer than 15 days before harvest, cutting or grazing. In California and Nevada do not use more than ¾ pint per acre.

COTTON—For control of thrips, use ¼ to ½ pint per acre. For cotton leafworms, use ¼ to ¾ pint per acre. For grasshoppers and fall armyworms up to third instar, use ⅓ pint per acre. For spider mites (does not control all species), use ½ to ¾ pint per acre. For control of fleahoppers, Lygus and other mirids, use ¼ pint to 1 quart per acre. For boll weevils, aphids and garden webworms, use ½ to 1 pint per acre. For false chinch bugs, use 1 pint per acre. For cabbage loopers and cutworms, use 1 to 2 pints per acre. For bollworms, salt marsh caterpillars, armyworms up to third instar, cotton leaf perforators and stink bugs, use 1 quart per acre. Applications should be made at 4 to 5 day intervals until control is obtained. At above dosages, application may be made up to the day before harvest, if harvest will be with mechanical pickers.

CAUTION—When necessary to enter treated cotton fields within 24 hours after application, protective clothing should be worn. Do not apply within 5 days of handpicking cotton.

GRASS (Forage)—For control of armyworms up to third instar, crested wheat bugs, false chinch bugs, grasshoppers and leafhoppers, use 1½ pints per acre. Do not apply within 15 days of harvest or grazing.

HOPS—For control of aphids and spider mites, use 1 quart per acre. Do not treat closer than 15 days before harvest.

SOYBEANS—For control of climbing cutworms and three-cornered alfafa hoppers, use ½ pint per acre. For control of garden webworms, use ½ to 1 pint per acre. For control of aphids, blister beetles, Mexican bean beetles, stink bugs, two spotted mites and velvet bean caterpillars, use 1 pint per acre. For bollworms, cabbage loopers, fall armyworms up to third instar, and green cloverworms, use 1 quart per acre. Do not apply closer than 20 days before harvest or grazing.

SUGAR BEETS—For aphids, armyworms up to third instar, flea beetles, leafhoppers, Lygus bugs, stink bugs and webworms, use ¾ pint per acre. Do not treat closer than 20 days before harvest, 60 days if tops are to be fed to livestock.

TOBACCO—For control of green peach aphids, use ½ pint per acre. For control of surface feeding or climbing cutworms, use ½ to 1 pint per acre.

CAUTION—When necessary to enter treated tobacco fields within 24 hours after application, protective clothing should be worn. Do not apply within 5 days of priming tobacco or within 15 days of cutting tobacco. Avoid contact with plant juices when priming or cutting tobacco.

VETCH—For control of aphids, armyworms up to third instar, climbing cutworms, leafhoppers, Lygus bugs, spider mites and vetch bruchids, use 1 to 2 pints per acre. Do not treat closer than 15 days before harvest or grazing.

FRUIT

APPLY AT THE RATES INDICATED FOR THE FOLLOWING CROPS. MAKE NO APPLICATION CLOSER THAN 14 DAYS BEFORE HARVEST. APPLY AS FREQUENTLY AS NEEDED TO CONTROL INSECTS.

APPLES—For control of aphids, codling moths, plum curculio, scales and red banded leaf rollers, use ½ pint to 1 quart per 100 gallons of water. For codling moths, plum curculio and red banded leaf rollers, apply at petal fall and 3 to 4 applications, 8 to 14 days thereafter, to maintain control. Do not use more than 6 quarts of this product per acre.

GRAPES—For control of aphids, grape leaf folders and grape leafhoppers, use ½ pint to 1 quart per 100 gallons of water. Do not use more than 1½ pints of this product per acre.

Table 19. (Continued)

PEACHES, PLUMS AND PRUNES—For control of aphids, peach tree borers, plum curculio and Oriental fruit moths, use ½ pint to 1 quart per 100 gallons of water. Spray tree trunks at time of moth flight to conrol peach tree borers. For plum curculio and Oriental fruit moths, apply at petal fall or shuck split and 3 to 4 applications, 8 to 14 days thereafter, to maintain control. Do not use more than 1 gallon of this product per acre.

STRAWBERRIES—For control of aphids, use 1 to 1½ pints per acre.

OIL SEED CROPS

SAFFLOWER—For aphids and Lygus bugs, use 1 pint per acre before flowering. Do not apply after flowering.

SUNFLOWER—For control of sunflower moth, use 1 quart per acre. Make no more than 3 applications at 5-day intervals. Do not apply within 30 days of harvest.

Fruit and Oil Seed Insects 15

Vegetable Insects 16

VEGETABLES

APPLY AT THE RATES INDICATED FOR THE FOLLOWING CROPS. MAKE NO APPLICATIONS CLOSER THAN 5 DAYS BEFORE HARVEST.

POTATOES—For control of aphids, armyworms up to third instar, cabbage loopers, false chinch bugs, flea beetles, leafhoppers, mites and shield bugs, use 1¼ quarts per acre.

SWEET POTATOES—For control of aphids, armyworms up to third instar, surface feeding and climbing cutworms, flea beetles, leafhoppers and mites, use ¾ quart per acre.

APPLY AT THE RATES INDICATED FOR THE FOLLOWING CROPS. MAKE NO APPLICATIONS CLOSER THAN 7 DAYS BEFORE HARVEST.

ARTICHOKE—For control of aphids, armyworms up to third instar, surface feeding and climbing cutworms, flea beetles, leafhoppers, mites and artichoke plume moths, use 1 quart per acre.

BROCCOLI—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers and mites, use 1 to 3 pints per acre. For cabbage loopers and stink bugs, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

BRUSSELS SPROUTS—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers and mites, use 1 to 3 pints per acre. For cabbage loopers and stink bugs, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

CAULIFLOWER—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers and mites, use 1 to 3 pints per acre. For cabbage loopers and stink bugs, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

KOHLRABI—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers and mites, use 1 to 3 pints per acre. For cabbage loopers and stink bugs, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

RUTABAGAS—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers and mites, use 1 to 3 pints per acre. For cabbage loopers, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

Vegetable Insects cont'd. 17

Vegetable Insects cont'd. 18

APPLY AT THE RATES INDICATED FOR THE FOLLOWING CROPS. MAKE NO APPLICATIONS CLOSER THAN 10 DAYS BEFORE HARVEST.

CABBAGE—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers and mites, use 1 to 3 pints per acre. For cabbage loopers and stink bugs, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

COLLARDS, KALE AND MUSTARD—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers and mites, use 1 to 3 pints per acre. For cabbage loopers and stink bugs, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

PEAS—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers, Lygus bugs and mites, use 1 to 2 pints per acre. For cabbage loopers, cowpea curculio, surface feeding and climbing cutworms and stink bugs, use 2 pints per acre. Rates above 1 pint should not be applied closer than 15 days before harvest.

TOMATOES—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers, mites and psyllids, use 1 to 3 pints per acre. For cabbage loopers, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 15 days before harvest.

Table 19. (Continued)

APPLY AT THE RATES INDICATED FOR THE FOLLOWING CROPS. MAKE NO APPLICATIONS CLOSER THAN 15 DAYS BEFORE HARVEST.

BEANS (Dry and Green)—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers, Lygus bugs and mites, use 1 to 3 pints per acre. For cowpea curculio, surface feeding and climbing cutworms and stink bugs, use 2 to 3 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

BEETS (Red)—For control of aphids, armyworms up to third instar, cabbage loopers, flea beetles, leafhoppers, Lygus bugs, mites and stink bugs, use 1 quart per acre. If tops are to be used for food or feed do not apply closer than 21 days before harvest.

CARROTS—For control of aphids, armyworms up to third instar, surface feeding and climbing cutworms, flea beetles, leafhoppers and mites, use 1 quart per acre. Do not feed tops.

CELERY—For control of aphids, armyworms up to third instar, cabbage loopers, flea beetles, leafhoppers, Lygus bugs, mites and stink bugs, use 1 quart per acre.

CUCUMBERS—For control of aphids and two-spotted mites, use ½ pint per acre. Do not apply before vining.

ONIONS—For control of thrips, use ½ pint per acre.

PEPPERS—For control of aphids, armyworms up to third instar, surface feeding and climbing cutworms, flea beetles, leafhoppers and mites, use 1 quart per acre.

SPINACH—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers, mites, seed corn maggots in crown and crown mites, use 1 to 2 pints per acre. For cabbage loopers, use 2 pints per acre. Rates above 1 pint should not be applied closer than 21 days before harvest.

TURNIPS—For control of aphids, armyworms up to third instar, flea beetles, leafhoppers, leaf miners and mites, use 1 to 1½ pints per acre. For cabbage loopers, use 1½ pints per acre. If tops are to be used for food or feed do not apply closer than 21 days before harvest.

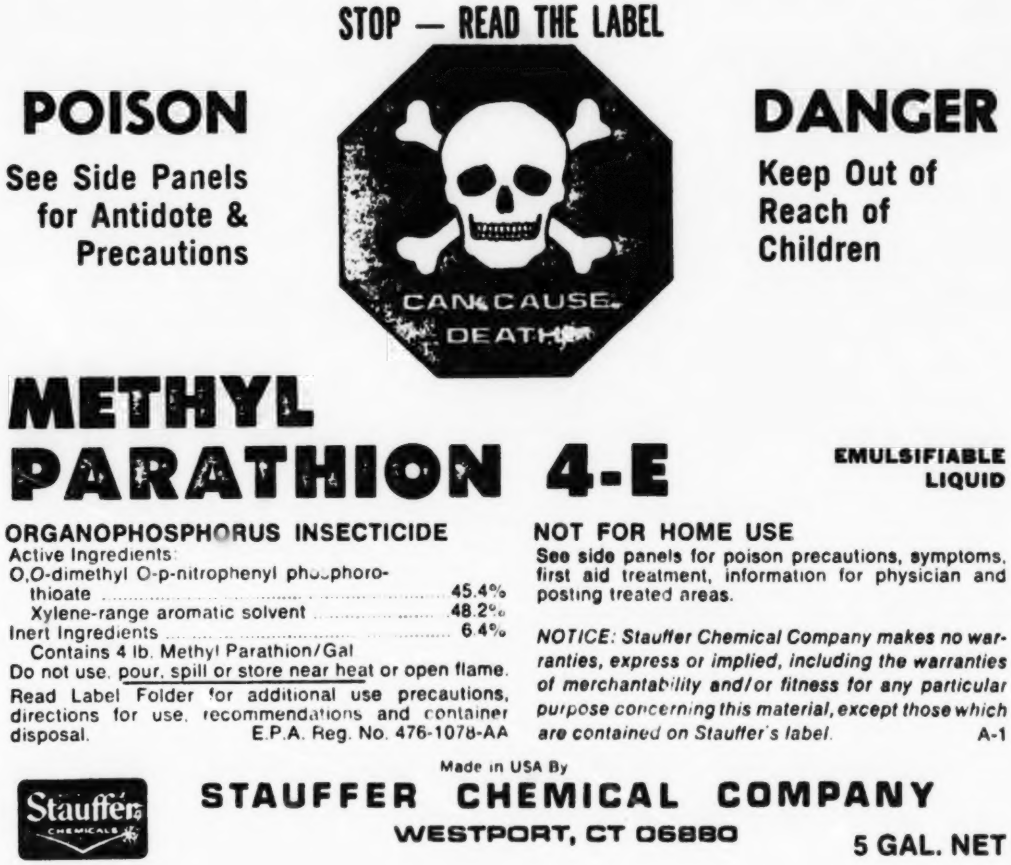
APPLY AT THE RATES INDICATED FOR THE FOLLOWING CROPS. MAKE NO APPLICATIONS CLOSER THAN 21 DAYS BEFORE HARVEST.

LETTUCE—For control of aphids, armyworms up to third instar, cabbage loopers, flea beetles, leafhoppers and mites, use 1 quart per acre.

896.11-000.17/53 (USDA Reg. No. 524-128)

MONSANTO COMPANY
AGRICULTURAL DIVISION
ST. LOUIS, MO. 63166

Table 20. REGISTERED USES OF METHYL PARATHION EMULSIFIABLE LIQUID (4 LB ACTIVE INGREDIENT PER GALLON) - CROPS AND OTHER USES, PESTS, DOSAGE RATES AND USE LIMITATIONS[a]



STOP — READ THE LABEL

POISON

See Side Panels for Antidote & Precautions

CAN CAUSE DEATH

DANGER

Keep Out of Reach of Children

METHYL PARATHION 4-E

EMULSIFIABLE LIQUID

ORGANOPHOSPHORUS INSECTICIDE

Active Ingredients:

O,*O*-dimethyl O-p-nitrophenyl phosphorothioate	45.4%
Xylene-range aromatic solvent	48.2%
Inert Ingredients	6.4%

Contains 4 lb. Methyl Parathion/Gal

Do not use, pour, spill or store near heat or open flame.

Read Label Folder for additional use precautions, directions for use, recommendations and container disposal. E.P.A. Reg. No. 476-1078-AA

NOT FOR HOME USE

See side panels for poison precautions, symptoms, first aid treatment, information for physician and posting treated areas.

NOTICE: Stauffer Chemical Company makes no warranties, express or implied, including the warranties of merchantability and/or fitness for any particular purpose concerning this material, except those which are contained on Stauffer's label. A-1

Made in USA By

STAUFFER CHEMICAL COMPANY

WESTPORT, CT 06880

5 GAL. NET

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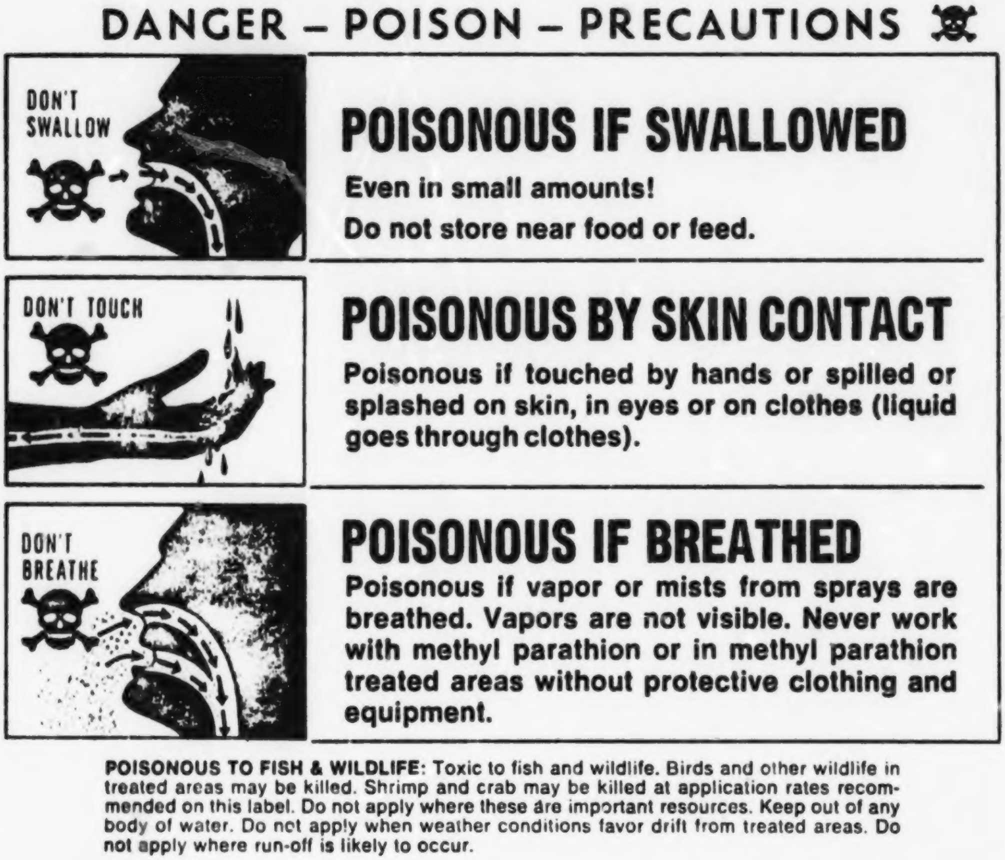
[a] Sample label of Stauffer Chemical Company.
EPA Registration No. 476-1078-AA.

Table 20. (Continued)



DANGER – POISON – PRECAUTIONS ☠

DON'T SWALLOW

POISONOUS IF SWALLOWED

Even in small amounts!

Do not store near food or feed.

DON'T TOUCH

POISONOUS BY SKIN CONTACT

Poisonous if touched by hands or spilled or splashed on skin, in eyes or on clothes (liquid goes through clothes).

DON'T BREATHE

POISONOUS IF BREATHED

Poisonous if vapor or mists from sprays are breathed. Vapors are not visible. Never work with methyl parathion or in methyl parathion treated areas without protective clothing and equipment.

POISONOUS TO FISH & WILDLIFE: Toxic to fish and wildlife. Birds and other wildlife in treated areas may be killed. Shrimp and crab may be killed at application rates recommended on this label. Do not apply where these are important resources. Keep out of any body of water. Do not apply when weather conditions favor drift from treated areas. Do not apply where run-off is likely to occur.

Table 20. (Continued)

WORK SAFETY RULES

USE ONLY WHEN WEARING THE FOLLOWING PROTECTIVE CLOTHING AND EQUIPMENT: (1) Wear waterproof pants, coat, hat, rubber boots or rubber overshoes. (2) Wear safety goggles. (3) Wear mask or respirator approved by the U. S. Bureau of Mines for methyl parathion protection. (4) Wear heavy duty natural rubber gloves.

Keep unprotected persons and children away from treated area or where there is danger of drift.

Do not rub eyes or mouth with hands. Do not smoke. Before removing gloves, wash them with soap and water. If you feel sick in any way STOP work and get help right away. Tell foreman or have someone call him. Call a physician, clinic or hospital immediately.

ALWAYS wash hands, face and arms with soap and water before smoking, eating or drinking.

AFTER WORK, take off all work clothes and shoes. Shower, using soap and water. Wear only clean clothes when leaving job. **DO NOT** wear contaminated work clothing.

All protective clothing and equipment should be washed with soap and water after each use. Respirators should be cleaned and filter replaced according to instructions included with respirator.

POISON SIGNS (Symptoms)

Methyl parathion is a very dangerous poison. It rapidly enters the body on contact with all skin surfaces, eyes and by contact with skin through wet clothes. Worker who shows any of the following poisoning signs must receive immediate medical treatment or he may die.

Signs and Symptoms of Poisoning Are: Headache, nausea, vomiting, cramps, blurred vision, pin-point pupils, tightness of chest, labored breathing, weakness, nervousness, sweating, watering of eyes, drooling or frothing of mouth and nose, muscle spasms and coma.

POSTING TREATED AREA: Consult state regulatory agencies for posting regulations and requirements.

FIRST AID TREATMENT

Speed is essential to stop absorption of poison. If possible, one person should make telephone calls while another begins treatment.

Call a physician, clinic or hospital immediately **in all cases of suspected poisoning.** Explain victim exposed to methyl parathion; describe his condition. **Until medical help is available take following steps.**

IF BREATHING HAS STOPPED, start artificial respiration immediately and continue until physician sees victim.

IF SWALLOWED and victim is awake (conscious) make him vomit quickly. First, give soapy water or strong salty water to drink then stroke back of throat with finger to make victim vomit. Repeat by giving more water and make vomit again until vomit fluid is clear. **Never give anything by mouth to an unconscious person.** Have victim lie down and keep quiet.

IN CASE OF SKIN CONTACT, immediately remove wet clothing and shoes and flush skin with water for at least 15 minutes.

EYE CONTACT: If splashed in eyes, immediately flush eyes with water for at least 15 minutes.

After first aid is given and physician can not come take victim to clinic or Hospital. Bring "Label Folder." Give to physician.

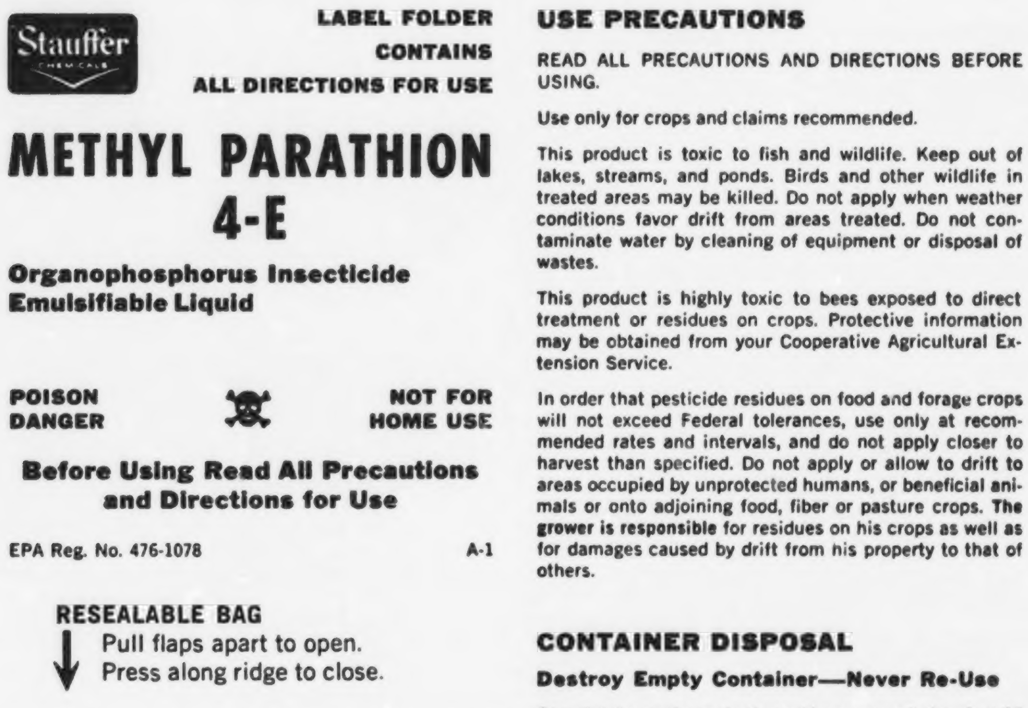
NOTE TO PHYSICIAN

ANTIDOTE—Administer **atropine sulfate** in large doses, 2.0 to 4.0 mg. intravenously or intramuscularly as soon as cyanosis is overcome. Repeat at 5 to 10 minute intervals until signs of atropinization appear. **2-PAM chloride** is also antidotal and may be administered in conjunction with atropine. **Do not give morphine or tranquilizers.**

Methyl parathion is a strong cholinesterase inhibitor affecting the central and peripheral nervous system, producing cardiac and respiratory depression.

At first signs of pulmonary edema, the patient should be given supplemental oxygen and treated symptomatically. Continued absorption of the poison may occur and fatal relapses have been reported after initial improvement. Very close supervision is indicated for at least 48 to 72 hours.

Table 20. (Continued)



Stauffer CHEMICALS

LABEL FOLDER
CONTAINS
ALL DIRECTIONS FOR USE

METHYL PARATHION 4-E

Organophosphorus Insecticide
Emulsifiable Liquid

POISON **NOT FOR**
DANGER ☠ **HOME USE**

Before Using Read All Precautions and Directions for Use

EPA Reg. No. 476-1078 A-1

RESEALABLE BAG
↓ Pull flaps apart to open.
Press along ridge to close.

IMPORTANT

SEE REVERSE SIDE OF FOLDER. CONTAINS SAFETY LABELING INFORMATION.

- Active Ingredient Statement
- Primary Statements of Hazard, Precautionary Instructions
- Fish and Wildlife Precautions
- Work Safety Rules
- Poison Symptoms
- First Aid Treatment
- Note to Physician

STAUFFER CHEMICAL COMPANY
WESTPORT, CT. 06880

USE PRECAUTIONS

READ ALL PRECAUTIONS AND DIRECTIONS BEFORE USING.

Use only for crops and claims recommended.

This product is toxic to fish and wildlife. Keep out of lakes, streams, and ponds. Birds and other wildlife in treated areas may be killed. Do not apply when weather conditions favor drift from areas treated. Do not contaminate water by cleaning of equipment or disposal of wastes.

This product is highly toxic to bees exposed to direct treatment or residues on crops. Protective information may be obtained from your Cooperative Agricultural Extension Service.

In order that pesticide residues on food and forage crops will not exceed Federal tolerances, use only at recommended rates and intervals, and do not apply closer to harvest than specified. Do not apply or allow to drift to areas occupied by unprotected humans, or beneficial animals or onto adjoining food, fiber or pasture crops. **The grower is responsible for residues on his crops as well as for damages caused by drift from his property to that of others.**

CONTAINER DISPOSAL

Destroy Empty Container—Never Re-Use

Completely empty contents and bury unused chemical 18 inches deep in an isolated location away from water supplies.

Glass Container: Break container and bury 18 inches deep.

Metal Containers: 1 gal. drum: Pour 1 quart of water into empty drum. Add 1 tablespoon of household detergent. Rotate drum carefully until all inner surfaces are wet. Bury rinse solution 18 inches deep. Punch holes in top and bottom of container, crush and bury. **5 gal. drum:** Pour 2 quarts of water into empty drum. Slowly add ½ cup caustic soda (lye) and 2 tablespoons of household detergent, follow the same rinsing, destruction and burial procedures given for 1 gal. drum. **55 gal. drum:** Follow same procedures as for 5 gal. drum except use 5 gal. water, 2 lb. of lye and cup of detergent.

CAUTION: Do not get rinse solution on hands, in eyes or on clothing. Wear protective clothing and equipment. In case of contact wash immediately with soap and water.

DIRECTIONS FOR USE

Application can be made by aircraft (except when not recommended for certain tree fruits) or ground power equipment by trained personnel only using approved protective equipment. Do not apply with hand equipment. Pour specified amount of this product into nearly filled spray tank. Add balance of water to fill tank. Keep agitator running during filling and spraying operations. If mixture does not mix readily, but tends to separate as an oily layer, do not use as injury to plants may result. Do not combine with wettable powders unless previous use of the mixture has proven physically compatible and safe to plants. **Always** thoroughly emulsify this product with at least half of total water **before** adding wettable powder.

SUGGESTED WATER RATES FOR AIRCRAFT AND GROUND EQUIPMENT

The actual rate required to provide thorough, uniform coverage varies with plant growth at time of application.

Except as specified for certain uses, the following rates are therefore intended to cover a broad range of conditions.

Crop	Gal. Water/Acre Aircraft	Ground
Vegetable and Field Crops	5-20	20- 125
Orchard	10-40	—
Orchard Crops (See exceptions below)	—	300- 800
Citrus	—	500-3000

Maximum permissible rate per acre, expressed as METHYL PARATHION 4-E, is given in parenthesis ( ), after each crop claim. Maximum permissible rates per acre and corresponding limitations are listed as a ready reference of legal limits for occasions when rates higher than those recommended are necessary to control unusual infestations. Consult State Agricultural Experiment Stations or Cooperative State Extension Services for additional information as the timing of applications may vary with local conditions.

IMPORTANT: Regardless of the type of equipment used and the volume of water required to make full coverage sprays for tree fruit and nut crops, or to make uniform applications on vegetable and field crops, do not apply more than the maximum permissible rate per acre as specified for each crop claim.

RECOMMENDATIONS

FRUIT CROPS

Before reading the following crop claims, rates and restrictions, first read the labeling section titled DIRECTIONS FOR USE.

Do not use on apples, apricots and pears when foliage is wet and under slow drying conditions, especially when aircraft or concentrate sprays are used.

Unless otherwise specified, rates are given in terms of METHYL PARATHION 4-E per 100 gal. of water for thorough coverage application.

APPLES: European red mite (apply twice at 5 day intervals), woolly apple aphid, rosy and green aphids. Use ½ pt. Injury to fruit and foliage may occur on McIntosh, Courtland and related varieties. Consult State Agricultural Extension Service. Do not apply within 14 days of harvest. (12 pt.)

APRICOTS: European red mite (apply twice at 5 day intervals), and green peach aphid. Use ½ pt. Do not apply within 14 days of harvest. Do not apply until danger of bee poisoning has passed. (5 pt.)

CHERRIES: European red mite, black cherry aphid. Use ½ pt. Apply as needed at 7 to 10 day intervals. Do not apply within 14 days of harvest. (5 pt.)

PEACHES: European red mite (apply twice at 5 day intervals), green peach aphid. Use ½ pt. Do not apply within 14 days of harvest. (8 pt.)

PEARS: Aphids. Use ½ pt. Apply twice at 5 day intervals. Do not apply within 14 days of harvest. (6 pt.)

PLUMS, PRUNES: European red mite (apply twice at 5 day intervals), green peach aphid and mealy plum aphid. Use ½ pt. Do not apply within 14 days of harvest. (8 pt.)

VEGETABLE, FIELD AND SPECIAL USES

(ALSO READ DIRECTIONS FOR USE)

Unless otherwise indicated, dosages are given in pints per acre in sufficient water to provide thorough coverage. Begin applications when insects first appear and repeat at 7 to 10 day intervals as needed to maintain control, but observe use limitations given for specific crops.

EXPLANATORY COMMENTS

ARMYWORMS — Recommendation applies only for control up to 3rd instar stage.

ALFALFA HAY: Alfalfa weevil larvae, aphids, armyworms, flea beetles, leafhoppers. Use 1 pt. (Calif. use ¾ pt. only) per acre. For weevil control apply when 75% of terminals show feeding damage. Do not apply within 15 days of harvest. **(Areas other than Calif.,** 2½ pt. Do not apply this rate within 20 days of harvest. **Calif.,** ¾ pt.)

CAUTION — Do not apply during bloom to avoid injury to bees. Birds and other wildlife in treated areas may be killed.

ALFALFA (FOR SEED): Alfalfa chalcid, aphids, armyworms, flea beetles, leafhoppers, lygus, mites and stinkbugs. Use ½-1½ pt. per acre by aircraft or ground equipment at first sign of infestation. Do not apply within 15 days of harvest. **Water Rates per Acre:** Aircraft — 5 to 10 gal.; ground — 25 to 100 gal. (2½ pt.)

CAUTION — When applied to seed crops, treat in early morning or late evening to avoid injury to pollinators.

ALFALFA, CLOVER, VETCH: Spotted alfalfa aphids. Use ½ to 1 pt. (Calif. use ¾ pt. only). Apply in early spring. Follow state recommendations. For the control of aphids, armyworms, leafhoppers and mites. Use 2½ pt. per acre (¾ pt. only in Calif.). Do not apply within 20 days of harvest (15 days in Calif.). **(Areas other than Calif.,** 2½ pt.; **Calif.,** under ¾ pt.)

CAUTION — Do not apply during bloom. Birds and other wildlife in treated areas may be killed.

ARTICHOKES: Aphids, armyworms, artichoke plume moth (use 2 pt. by air in a minimum of 10 gal. water per acre),

Table 20. (Continued)

flea beetles, mites. Use 1¼ pt. Do not apply within 7 days of harvest. (2 pt.)

BEANS, DRY: Aphids, armyworms, flea beetles, mites. Use 2 pt. Do not apply within 15 days of harvest. (3 pt.)

BEANS, GREEN AND LIMA: Aphids, armyworms, flea beetles, mites. Use 1 to 2 pt. **Rate and use limitation:** 1 pt., 15 days of harvest; over 1 pt. to 2 pt., 21 days of harvest. (3 pt.)

BEETS: Aphids, armyworms, flea beetles, leafhoppers, mites. Use 1 to 1¾ pt. per acre. Do not apply within 15 days of harvest (21 days if tops are to be used as food). (2 pt.)

CABBAGE: Aphids, armyworms, flea beetles. Use 1 to 1½ pt. Do not apply within 21 days of harvest. (3 pt.)

CARROTS: Aphids, armyworms. Use 1 to 1¼ pt. Do not apply within 15 days of harvest. Do not use treated tops for food or feed. (2 pt.)

CELERY: Aphids, armyworms. Use 1 to 1¼ pt. Do not apply within 15 days of harvest. (2 pt.)

COLE CROPS (Broccoli, Brussels sprouts, cauliflower, collards, kale, kohlrabi): Aphids, armyworms, flea beetles. Use 1 pt. Do not apply within 10 days of harvest on collards and kale; 7 days on broccoli, Brussels sprouts, cauliflower and kohlrabi. (1 pt.)

CORN (fodder and grain, including field, sweet and popcorn): Aphids, armyworms, flea beetles, mites. Use ½ pt. Repeat application if necessary. Workers entering treated fields the day of application should wear protective clothing. Do not apply within 12 days of harvest. (½ pt.)

COTTON: Aphids, boll weevil, cotton leafworm, fleahopper, lygus, red spider mites, thrips. Use ½ to 1 pt. Application should be made at 4 to 5 day intervals until control is obtained. For the control of cotton leaf perforator, armyworms use 2½ pt.

Cotton bollworm control **(Calif. only):** Apply 2 to 6 pt. by aircraft in 3 to 5 gal. of water per acre. Make this application 2 or 3 times at 3 to 4 day intervals. Depending on infestation, repeat this series of 2 or 3 applications in 7 to 10 days or more, as needed to maintain control. Do not sprinkle irrigate during the 3 to 4 day application intervals. Late afternoon or evening treatments are preferred.

Cotton bollworm, tobacco budworm (cotton south): Use 2 pt.

Workers entering treated fields within 24 hours of application should wear protective clothing. Do not apply within 7 days of hand picking or harvest. (6 pt.)

GOOSEBERRIES: Aphids. Use ½ pt. Do not apply within 15 days of harvest. (½ pt.)

HOPS: Aphids, armyworms, leafhoppers, mites. Use 1 pt. Do not apply within 15 days of harvest. (2 pt.)

LETTUCE: Aphids, armyworms. Use 1 to 1¼ pt. Do not apply within 21 days of harvest. (2 pt.)

ONIONS: Onion thrips. Use 1 pt. in 15 gal. of water for aircraft application; 10 to 25 gal. by ground equipment. Repeat at weekly intervals. Do not apply within 15 days of harvest. (1¾ pt.)

PEANUTS: Leafhoppers, lesser cornstalk borer, red-necked peanutworm, spider mites, three-cornered alfalfa hopper, webworm. Use 1-3/5 pt. Do not apply within 15 days of harvest. (1-3/5 pt.)

POTATOES: Aphids, armyworms, flea beetles, mites. Use 2 pt. Do not apply within 5 days of harvest. (3 pt.)

PEAS: Aphids, armyworms. Use 1 pt. Do not apply within 10 days of harvest. (1 pt.)

PEPPERS: Aphids, armyworms. Use 1 to 2 pt. Do not use within 15 days of harvest. (2 pt.)

RICE (Calif. only): Rice leaf miner and tadpole shrimp. Apply at the first sign of infestation after planting using 1½ pt. in 5 to 10 gal. water by aircraft. Restrict spill from rice fields for 5 days. Do not apply within 15 days of harvest. **CAUTION:** Do not use within 14 days of application of Stam F-34 or Rogue. Injury may result. Shrimp and crab may be killed at these rates. Do not apply where these are important resources. (1½ pt.)

SAFFLOWER: Aphids and lygus bugs. Use 1 pt. Do not apply after flowering. (1 pt.)

SMALL GRAINS (Barley, oats and wheat): Aphids (green bug), black grass bug (Irbisia), brown wheat mite (Petrobia), and stink bugs. Apply ½ to 1 pt. For armyworms and leafhoppers apply 2½ pt. **Use limitations:** ½ pt. — none; over ½ and up to 1½ pt., 15 days.

SOYBEANS: Stink bugs, three-cornered alfalfa hopper and velvet bean caterpillar. Use ¾ to 1 pt. Do not apply more than 2 applications per growing season. Do not apply within 20 days of grazing or harvest. (2 pt.)

SPINACH:: Aphids, armyworms. Use 1 to 2 pt. **Rate and use limitation:** 1 pt. — do not apply within 14 days of harvest; over 1 pt. to 2 pt., 21 days of harvest. (2 pt.)

TOBACCO: Green June beetle. 1 pt. Do not apply within 5 days of priming tobacco or within 15 days of cutting tobacco. Avoid contact with plant juices when priming or cutting tobacco. Workers entering treated fields within 24 hours after application should wear protective clothing. (1 pt.)

TOBACCO PLANT BED DRENCH: Green June beetle. ⅜ pt. per 100 gal. water. Apply 100 gal. of drench per 100 sq. yd. Apply to plant beds with sprinkling can. Application should be made only by trained operator. Do not apply within 5 days of transplanting.

TOMATOES: Aphids, armyworms, flea beetles, russet mite. Use ½ to 1 pt. **Rate and use limitation:** 1 pt., do not apply within 10 days of harvest; over 1 pt. to 3 pt., 15 days of harvest. (3 pt.)

TURNIPS (Coastal area of Calif.): (Foliage treatment) cabbage aphids. Apply 1½ pt. when aphids are present and colonies are abundant. Repeat as necessary to maintain control but do not apply within 15 days of harvest (21 days if tops to be used for food or feed). (1-3/5 pt.)

FOREST AND CHRISTMAS TREE PLANTINGS: To control European pine shoot moth and Nantucket pine tip moth use 2 pt. per acre in 5 to 50 gal. water. Repeat applications if necessary.

It is unlawful in California to sell or deliver methyl parathion-containing pesticide products to any person required to be in possession of a permit under this code, unless the person or his agent signs a statement that he indeed has a valid permit to use the product.

Similar restrictions on the use of methyl parathion are in effect in a number of other states.

Details of the pesticide use and application laws in each of the states that regulate pesticides have been summarized by EPA, Office of Pesticide Programs, in a publication entitled Guide for Analyzing Laws. This pesticide law digest is being kept current by addition and replacement pages issued to holders from time to time.

In addition to these statutory restrictions on the use of methyl parathion imposed by Federal and state laws, many states amplify methyl parathion product labels by issuing further, more specific use recommendations or suggestions designed to accommodate local or regional requirements. These are usually issued jointly by the State Agricultural Experiment Station and Extension Service in cooperation with the U.S. Department of Agriculture. These state insecticide use recommendations or suggestions are issued or revised annually.

Production and Domestic Supply

Volume of Production - The United States Tariff Commission 1972 final report on synthetic organic chemicals[1] listed the following production volumes of methyl parathion for the period 1967-1972.

Year	Production volume (active ingredient)
1967	33,344,000 lb
1968	38,163,000 lb
1969	50,572,000 lb
1970	41,353,000 lb
1971	37,226,000 lb
1972	51,076,000 lb

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[1] U.S. Tariff Commission, Synthetic Organic Chemicals, U.S. Production and Sales, 1972, TC Publication 681 (1973).

The Tariff Commission named four basic producers of methyl parathion in the United States: Monsanto Company, Stauffer Chemical Company, Kerr-McGee Chemical Corporation, and Velsicol Chemical Corporation.

According to Midwest Research Institute[1] estimates, Monsanto produced about 25 million pounds of methyl parathion in 1972; Stauffer about 15 million pounds; Kerr-McGee about 8 million pounds; and Velsicol about 3 million pounds.

Imports - Imports of pesticides classified as "benzenoid chemicals" (including methyl parathion) are reported in a 1973 U.S. Tariff Commission annual report[2]. According to the report, 1,102,300 lb of methyl parathion were imported into the United States in 1972.

Exports - Pesticide exports are reported by the Bureau of the Census annually. Technical (unformulated) methyl parathion and parathion are included in this report in Schedule B, Section 512.0652. Formulations of methyl parathion (and of all other cyclic and acyclic organic phosphate insecticides) are included in Schedule B, Section 599.2035, entitled "Organic Phosphate Containing Pesticidal Preparathions, Except Household and Industrial and Except Fly Sprays and Aerosols."[3]

Total exports of organic phosphate insecticides in these two categories for 1972 were as follows:

Section 512.0652 (methyl parathion and parathion technical)	16,533,940 lb
Section 599.2035 (organic phosphate containing formulations)	15,898,884 lb

To derive the 1972 export volume of methyl parathion from these composite totals, Midwest Research Institute made a thorough analysis of these two pesticide export categories by unit dollar values and by countries of destination. In the next step, this information was matched against existing knowledge of the crop protection problems and the pesticide trading patterns of the countries of destination. Additional information was obtained from confidential sources, from the U.S. Agency for International Development (AID), and from other sources. Based on this data the 1972 export volume of methyl parathion is estimated at 12.5 million pounds of active ingredient.

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[1] Midwest Research Institute/RvR Consultants, "Production, Distribution, Use, and Environmental Impact Potential of Selected Pesticides" (draft), Council on Environmental Quality, Contract No. EQC-311 (15 March 1974).

[2] U.S. Tariff Commission, Imports of Benzenoid Chemicals and Products, TC Publication 601 (1973).

[3] U.S. Bureau of the Census, U.S. Exports, Schedule B, Commodity by Country, Report FT 410.

Domestic Supply - The information presented in the preceding three sections permits an estimate of the domestic supply of methyl parathion in the U.S. in 1972. Adding imports to production, and subtracting exports, Midwest Research Institute estimates that 39,700,000 lb of methyl parathion active ingredient were used domestically in 1972.

Comparable estimates for 1973 cannot be made at this time because the U.S. Tariff Commission Report on the production and sales of pesticides and related products in 1973 was not available at the time of review.

Formulations - Methyl parathion is available to users in the United States in several different formulations, and through a considerable number of suppliers. The basic producers of technical methyl parathion sell a large share of their production to formulator-customers in the form of an 80% technical solution. Formulators then prepare and sell formulations containing methyl parathion under their own labels and brand names to end users, either directly, or through wholesalers and/or retailers.

In areas of heavy use of methyl parathion-toxaphene combinations, the two ingredients are often mixed and formulated in bulk and dispensed into spray equipment directly from bulk tanks in the field, thus bypassing drums, cans, and the problem of disposal of these containers after use.

Frear (1972)[1] lists more than 30 pesticide products containing methyl parathion as the only active ingredient. These include 27 sprayable formulations, 3 dust formulations, and 4 manufacturing concentrates. No granular or aerosol formulations of methyl parathion are listed (or registered). Among the spray formulations, those containing concentrations offered are 2%; 2 lb/gal.; 3.2 lb/gal.; and 4.25 lb/gal. Also offered, are 70 and 80% technical solutions and at least one 25% wettable powder formulation.

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[1] Frear, D. E. H., Pesticide Handbook - Entoma, 24th Edition, College Science Publishers, State College, Pennsylvania (1972).

In addition, there are a considerable number of liquid and some dry formulations containing methyl parathion in combination with other insecticides and/or fungicides. Among these combination formulations, an emulsifiable liquid containing 3 lb of methyl parathion and 6 lb of parathion per gallon has recently made considerable gains in volume of use. It is the only formulated parathion or methyl parathion product currently marketed by Monsanto, the largest U.S. producer of both products. Similar parathion-methyl parathion emulsifiable liquids are offered by at least two other formulators.

Use Patterns of Methyl Parathion in the United States

General - The entire volume of methyl parathion used in the United States in 1972 (the most recent year for which sufficient data for such estimates are available) was used in agriculture. There were no significant uses of methyl parathion by industrial, commercial, or institutional pesticide users; by Federal, state, county, local or other governmental agencies; or by home and garden users.

Surveys on the use of pesticides by farmers in the United States were conducted by the U.S. Department of Agriculture in 1964, 1966, and 1971 (Agricultural Economic Reports No. 131, published in 1968; No. 170, published in 1970; and No. 252, in press and soon to be published). Data on the uses of methyl parathion in 1972 were obtained by RvR Consultants.

The following farm uses of methyl parathion were reported:

Year	Source	Farm Use
1964	USDA	9,985,000 lb of active ingredient
1966	USDA	8,002,000 lb of active ingredient
1971	USDA	27,563,000 lb of active ingredient
1972	RvR	39,700,000 lb of active ingredient

These figures indicate a sharp upward trend in the rate of use of methyl parathion by farmers between 1964-66 and the present.

As outlined in detail in the first part of this subsection, methyl parathion controls a considerable number of insect pests, and some mite species. The 40-page section on methyl parathion in the "EPA Compendium of Registered Pesticides," Vol. III, pages D-41.1 through 41.40, includes 62 crops and other uses for which methyl parathion is registered.

Table 21 presents a breakdown of the estimated uses of methyl parathion in the United States in 1972 by regions and major crops. The following information sources were used in arriving at these estimates:

1. The 3 USDA surveys of pesticide uses by farmers mentioned above.

2. The annual USDA publication "Pesticide Review" (Agricultural Stabilization and Conservation Service).
3. Results of a survey of the Federal/State Cooperative Extension Services in all 50 states and in Puerto Rico conducted by RvR Consultants in 1973.
4. Analyses of state pesticide use recommendations.
5. Local and regional estimates on pesticide use volumes obtained from State Research and Extension personnel in personal communications.
6. Pesticide use reports from the states of Arizona, California, Illinois, Indiana, Michigan, Minnesota, and Wisconsin.
7. Data on pesticide uses supplied by the EPA Community Pesticide Studies Projects in Arizona, Hawaii, Idaho, Mississippi, South Carolina, Texas, and Utah.
8. Estimates and information obtained from basic producers of parathion and other pesticides, and from pesticide trade sources.
9. Pesticide use surveys conducted recently by Wallaces' Farmer, Des Moines, Iowa; Prairie Farmer, Chicago, Illinois; and Wisconsin Agriculturist, Madison, Wisconsin.
10. "Agricultural Statistics," an annual publication of the U.S. Department of Agriculture.

Data from these diverse sources were carefully analyzed, correlated, cross-checked and cross-validated. The resulting estimates as summarized in Table 21 are believed to be the best and most up-to-date information on the use patterns of methyl parathion in the United States currently available.

Methyl Parathion Use Patterns by Regions - Close to 80% of the estimated total domestic use of methyl parathion, i.e., about 31 million pounds of AI, were used in 1972 in the South Central Region, primarily on cotton. An estimated 2.1 million pounds of the product were used on soybeans in the East South Central states, and much smaller quantities on a variety of other field and vegetable crops.

The Southeastern states used an estimated 5.0 million pounds of methyl parathion. Of this total, about 3.7 million pounds were used on cotton, about 900,000 lb on soybeans, the balance (400,000 lb) on a variety of other crops.

Table 21. ESTIMATED USES OF METHYL PARATHION IN THE U.S. BY REGIONS AND MAJOR CROPS, 1972

Region	Crop					
	Cotton	Soybeans	Other field crops	Vegetables	All other crops and uses	Totals, all uses
	Thousands of pounds of active ingredient					
Northeast[a]	--	--	Negl.	Negl.	Negl.	Negl.
Southeast[b]	3,700	900	100	100	200	5,000
North Central[c]	Negl.	100	Negl.	Negl.	Negl.	100
East South Central[d]	13,500	2,100	100	100	200	16,000
West South Central[e]	14,600	Negl.	100	100	200	15,000
Northwest[f]	--	--	450	100	150	700
Southwest[g]	1,700	--	500	500	200	2,900
Totals, 50 states	33,500	3,100	1,250	900	950	39,700

Sources: RvR estimates; see text.

[a] New England States, New York, New Jersey, Pennsylvania

[b] Maryland, Delaware, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida

[c] Ohio, Indiana, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Illinois

[d] Kentucky, Tennessee, Arkansas, Louisiana, Mississippi, Albama

[e] Oklahoma, Texas

[f] Montana, Idaho, Wyoming, Colorado, Utah, Washington, Oregon, Alaska

[g] New Mexico, Nevada, Arizona, California, hawaii

An estimated 2.9 million pounds of methyl parathion were used in the Southwestern states. Again, cotton accounted for the largest share of this total (1.7 million pounds), while the remaining 1.2 million pounds were used on field, vegetable, and other crops.

An estimated 700,000 lb of methyl parathion AI were used in the Northwest in 1972, primarily on field crops (small grains, alfalfa, sugar beets), the balance going on vegetable and other crops.

An estimated 100,000 lb of methyl parathion were used in the North Central states in 1972, primarily on soybeans.

There were no significant uses of methyl parathion in the Northeast in 1972.

Methyl Parathion Use Patterns by Crops - Methyl parathion is primarily a cotton insecticide. Cotton accounts for about 85% of the total quantity of methyl parathion used in the United States in 1972. Methyl parathion is registered and recommended against 20 different insect and mite pests on cotton. In 1972, many pesticide suppliers in the "cotton south" reported selling record quantities of cotton insecticides that year, especially toxaphene and methyl parathion. Methyl parathion was short in supply in many places.

An estimated 3.1 million pounds of methyl parathion AI were used on soybeans in 1972. The largest share of this total was used in the East South Central states, followed by the Southeastern states, with only about 100,000 lb used on Northern soybeans. Methyl parathion use on soybeans was probably much larger in 1973 because of an outbreak of the green cloverworm in the Northern soybean growing areas.

Other field crops (including small grains, alfalfa, sugar beets, rice, and others), vegetable crops (including artichokes, tomatoes, lettuce, beans, and others), and other crops and uses account for the remaining quantities of methyl parathion used in the United States in 1972.

Methyl Parathion Uses in California - The State maintains detailed records of pesticide uses by crops and commodities which are published quarterly and summarized annually. Table 22 summarizes the uses of methyl parathion in California by major crops for the 4-year period 1970-1973. The total volume of methyl parathion used during this period varied from about 730,000 lb in 1973 to 1,011,000 lb in 1971. Quantities used on individual crops showed even greater variations. For instance, the use of methyl parathion on cotton declined from 224,000 lb in 1970 to 90,000 lb in 1973. Methyl parathion quantities used on artichokes varied from 77,000 lb in 1971 to 151,000 lb in 1973.

Methyl parathion has also been used extensively for vector control (mosquito larvae) in California. However, quantities used have declined from 221,000 lb in 1970 to 34,000 lb in 1973.

Table 22.* METHYL PARATHION USES IN CALIFORNIA BY MAJOR CROPS AND OTHER USES, 1970-1973

Crop	Year 1973	1972	1971	1970
	Thousands of pounds of active ingredient			
Almonds	5[a]	1	--	--
Artichokes	151	199	77	114
Beans	31	39	30	17
Tomatoes	94	62	87	49
Lettuce	70	54	53	73
Cotton	90	145	346	224
Sugar beets	53	59	87	37
Alfalfa	49	51	106	62
Rice	32	23	30	15
Vector control	34	52	63	221
All other uses	121	84	132	118
Totals	730[a]	769	1,011	930

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*California Department of Agriculture, Pesticide Use Reports for 1970, 1971, 1972, and 1973.

[a] Quantity used on almonds in 1973 and 1973 total reduced by 474,000 lb to adjust for apparent system error; see text.

Tables 23 and 24 present methyl parathion uses in California by crop, number of applications, pounds of active ingredient, and number of acres treated, for 1972 and 1973, respectively, the two most recent years for which such data are available. In both years, methyl parathion was used in California on about 75 different crops.

Regarding the California Department of Agriculture's reported figure of 478,595 pounds of methyl parathion used on the state's almond crops in 1973 (Table 24), available figures for the three preceeding years show that methyl parathion uses on almonds were considerably lower: 1970, 422 lb; 1971, 86 lb; 1972, 979 lb. Based on an analysis of past level of use and the number of acres treated in 1973, Midwest Research Institute has revised the reported 1973 figure for methyl parathion uses on almonds. (See Table 22.) *

At the present time, no other state records or publishes pesticide use data in a form or detail comparable to that of California. Limitations of time and resources did not permit development for this review of estimates on the uses of methyl parathion by crops and states.

Summary - In 1972, almost 40 million pounds AI of methyl parathion were used in the United States. Of this total, about 85% (33.5 million pounds) were used on cotton; 3.1 million pounds on soybeans; the balance on other field crops, vegetables, and on other crops and for other purposes, including control of mosquito larvae.

Geographically, about three-fourths of the total quantity of methyl parathion used in the U.S. in 1972 was used in the South Central states. The remaining one-fourth of the total methyl parathion volume was used (regions listed in decreasing order of volume of use) in the Southeast; the Southwest; the Northwest; and in the North Central states. There were no significant uses of methyl parathion in the Northeast in 1972.

In California, methyl parathion was used on about 75 different crops, and for the control of mosquito larvae. However, total use of methyl parathion in California amounted to less than 2% of the national total.

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* In a personal communication, the California Department of Agriculture agree that the reported figure of 478,595 lb was most likely erroneous. The agency did not account for the discrepancy.

Table 23. USE OF METHYL PARATHION IN CALIFORNIA IN 1972 BY CROPS, APPLICATIONS, QUANTITIES, AND ACRES TREATED

Commodity	Applications	Pounds	Acres
Alfalfa	988	31,314.81	86,197.70
Alfalfa for seed	123	20,097.15	16,029.00
Almond	10	978.86	669.00
Anise	1	13.16	15.00
Apple	3	85.00	34.00
Apricot	9	432.86	298.50
Artichoke	2,498	199,145.46	206,614.00
Barley	23	1,291.95	2,420.00
Beans, dry edible	526	38,134.44	42,872.50
Beans, green or forage	18	493.87	810.00
Beans for seed	3	29.98	143.00
Beet	147	4,859.64	10,375.68
Broccoli	120	2,136.17	2,371.90
Brussels sprouts	163	4,200.54	4,399.50
Cabbage	219	3,855.50	4,644.83
Cantaloupe	8	162.88	592.00
Cardoni (cardoon)	4	6.00	6.00
Carrot	294	9,941.93	10,676.45
Cattle lot	1	1.44	6.00
Cauliflower	276	3,811.87	5,108.50
Celery	803	14,044.81	13,317.05
Chinese cabbage	2	5.46	8.00
Citrus	16	776.78	445.50
Cole crops	2	4.00	8.00
Conifer	1	39.46	76.00
Corn/field	68	2,322.56	3,778.00
Corn/sweet	63	6,037.83	5,532.00
Cotton	2,016	145,003.04	184,639.90
County or city parks		7.48	
Crenshaw melon	1	7.30	10.00
Cucumber or pickle	2	23.49	105.00
Eggplant	1	11.08	15.00
Endive	2	11.08	15.00
Fallow (open ground)	13	305.80	354.00
Flowers	16	151.13	172.00
Grape	11	1,750.74	2,174.00
Leek	3	9.96	26.00
Lemon	7	395.24	146.00
Lettuce/head	2,397	53,717.46	87,004.27
Lettuce/leaf	76	600.61	912.75
Melons	3	180.09	310.00

Table 23.* (Continued)

Commodity	Applications	Pounds	Acres
Nectarine	50	654.97	400.00
Non-Agricultural areas	8	144.00	338.00
Nursery stock	1	32.67	50.00
Oats	2	54.25	100.00
Olive	20	1,381.62	389.50
Onion/dry	134	5,025.82	6,971.00
Onion/green/spring/shallot	26	575.69	614.00
Orange	78	6,741.13	2,390.41
Ornamentals	14	130.71	155.00
Ornamental bedding plants	2	32.75	38.00
Other agencies		338.75	
Pasture/rangeland	16	3,792.33	1,257.00
Peach	41	1,545.44	715.00
Pea	15	156.04	174.00
Pepper/bell	31	638.16	719.50
Plum	37	922.12	451.00
Potato	253	2,591.47	13,917.93
Prune	10	986.25	485.00
Pumpkin	1	26.25	100.00
Radish	4	49.38	57.00
Residential control		7.43	
Rice	232	23,311.59	41,144.61
Rye	1	25.98	70.00
Safflower	2	58.12	107.00
Salsify	1	2.32	29.00
Sorghum	32	742.75	2,174.50
Spinach	68	2,198.97	3,570.00
Squash, summer	4	38.26	74.50
Strawberry	13	547.58	565.00
Sudan grass	2	142.87	170.00
Sugar beet	1,688	58,991.44	136,235.88
Sunflower seed	1	180.74	160.00
Swiss chard	1	8.80	2.00
Tomato	1,118	61,646.95	65,840.00
Turf	16	1,230.90	1,801.00
Turnip	3	11.71	15.00
University of California		75.12	
Vector control		51,302.38	
Walnut	3	133.32	121.00
Water areas	2	69.99	379.00
Wheat	7	340.18	805.00
Total	14,874	768,603.17	975,917.86

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*California Department of Agriculture, Pesticide Use Report 1972.

Table 24. USE OF METHYL PARATHION IN CALIFORNIA IN 1973 BY CROPS, APPLICATIONS, QUANTITIES, AND ACRES TREATED

Commodity	Applications	Pounds	Acres
Alfalfa	851	30,426.49	77,405.30
Alfalfa for seed	292	18,132.82	23,197.00
Almond	18	478,595.34	2,859.58
Apple	2	37.25	27.00
Apricot	4	160.69	81.50
Artichoke	3,081	151,268.62	173,033.31
Asparagus	1	25.99	30.00
Avocado	2	124.20	155.00
Barley	63	5,216.31	13,470.00
Beans, dry edible	619	30,734.31	42,822.05
Beans, green or forage	3	51.65	141.00
Beet	485	14,496.72	38,376.40
Broccoli	222	3,820.23	4,144.14
Brussels sprouts	63	1,940.60	1,903.00
Cabbage	200	3,389.81	4,662.50
Cantaloupe	2	14.78	20.00
Cardoni (cardoon)	1	6.93	5.00
Carrot	279	10,255.21	10,926.72
Cattle lot	1	31.19	36.00
Cauliflower	332	5,435.99	5,839.24
Celeriac	2	66.80	46.00
Celery	748	14,000.19	12,222.17
Chinese cabbage	1	4.74	5.00
Citrus	1	62.50	25.00
Corn/field	21	656.58	1,772.00
Corn/sweet	22	547.07	2,364.00
Cotton	2,039	89,932.62	186,202.64
Cucumber or pickle	3	70.20	98.00
Eggplant	3	33.24	45.00
Fallow (open ground)	12	410.75	163.25
Flowers	6	1,023.60	871.00
Grape	20	869.36	1,670.00
Leek	2	11.86	27.00
Lemon	20	1,994.01	312.00
Lettuce/head	2,983	69,817.69	123,893.98
Lettuce/leaf	36	343.29	615.18
Melons	6	88.48	285.00
Nectarine	21	440.71	249.50
Non-Agricultural areas	2	80.72	205.00
Nursery stock	1	3.16	10.00
Olive	34	2,458.36	617.50
Onion/dry	188	8,544.64	10,393.00

Table 24.* (Continued)

Commodity	Applications	Pounds	Acres
Onion/green/spring/shallot	12	252.01	295.00
Orange	101	9,275.04	3,955.00
Ornamentals	47	621.20	743.00
Pasture/rangeland	13	264.94	1,772.00
Peach	67	3,729.29	2,382.75
Pear	4	6.50	13.00
Pea	144	450.23	669.50
Pepper/bell	31	653.02	827.50
Plum	24	597.63	257.50
Potato	172	11,435.73	12,246.50
Prune	14	1,608.05	745.25
Residential control		.24	
Rice	253	31,651.23	42,167.00
Safflower	14	959.39	2,534.00
Soil (fumigation only)	4	404.16	194.00
Sorghum	56	2,399.45	3,244.00
Spinach	48	1,260.69	1,710.06
Squash, summer	3	10.03	13.00
Squash, winter	1	18.71	100.00
State highway		3.86	
Strawberry	16	377.93	437.00
Sudan grass	3	21.57	96.00
Sugar beet	1,871	53,203.88	151,892.78
Sunflower seed	6	2,049.49	1,680.00
Sweet potato	28	739.18	1,574.00
Swiss chard	1	.26	2.00
Tangelo	2	40.50	13.00
Tomato	1,439	94,371.80	101,472.60
Turf	2	76.64	290.00
Turnip	5	27.91	41.00
University of California		72.83	
Vector control		34,197.97	
Walnut	4	50.89	64.00
Water areas	4	216.07	1,224.00
Wheat	231	7,349.05	14,156.00
Total	17,312	1,204,023.07	1,088,038.40

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*California Department of Agriculture, Pesticide Use Report 1973.

PART III. MINIECONOMIC REVIEW

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This section contains a general assessment of the efficacy and cost effectiveness of methyl parathion. Data on the production of methyl parathion in the United States as well as an analysis of its use patterns at the regional level and by major crop, were conducted as part of the Scientific Review (Part II) of this report. The section summarizes rather than interprets scientific data reviewed.

Introduction

The efficacy and cost effectiveness of a specific pesticide should be measurable in terms of the increased yield or improved quality of a treated crop which in turn results in a greater income or lower cost than would be achieved if the pesticide had not been used. Thus, one should be able to pick an isolated test plot of a selected crop, treat it with a pesticide, and compare its yield with that of a nearby untreated test plot. The difference in yield should be the increase due to the use of the pesticide. The increased income (i.e., the yield multiplied by the selling price of the commodity) less the additional costs (i.e., the pesticide, its application and the harvesting of the increased yield) is the economic benefit due to the use of the pesticide.

Unfortunately, this method has many limitations. The data derived is incomplete and should be looked on with caution. Midwest Research Institute's review of the literature and EPA registration files revealed that experimental tests comparing crops treated with specific pesticides to the same crop without treatment are conducted by many of the state agricultural experimental stations. Only a few of these, however, have attempted to measure increased yield and most of this effort has been directed toward just a few crops such as cotton, potatoes, alfalfa and selected fruits. Most other tests on crops measure the amount of reduction in pest levels which cannot be directly related to yield.

Even the test plot yield data are marginally reliable, since these tests are conducted under actual field conditions that may never be duplicated again and may not be representative of general field use. Thus yield is affected by rainfall, fertilizer use, severe weather conditions, soil type, region of the country, pesticide infestation levels and the rate, frequency and method of pesticide application.

Because of these factors, yield tests at different locations and in different years will show a wide variance ranging from a yield decline to significant increases. For example, in a year of heavy pest infestation frequent pesticidal use can result in a high yield increase because the crop from the untreated test plot is practically destroyed. Conversely, in a year of light (or insignificant) infestation, the yield increase will be slight (or undetectable).

Thus the use of test plot yield data is at best qualitative and is used for order-of-magnitude economic cost and benefit determination.

The use of market price to estimate the value received by the producer also has its limitations. If the use of the pesticide increases the yield of a crop and the national production is increased, then the market price should decline. According to J. C. Headley and J. N. Lewis (1967),[1] a 1% increase in quantity marketed has at times resulted in a greater than 1% decrease in price. Thus the marginal revenue from the increased yield would be a better measure of value received.

A third limitation to the quantification of the economic costs and benefits is the limited availability of data on the quantities of the pesticide used by crop or pest, the acres treated, and the number of applications. In most cases the amount of methyl parathion used on each crop or each pest is not available.

As a result of these limitations an overall economic benefit by crop or pest cannot be determined. This report presents a range of the potential economic benefits derived from the use of methyl parathion to control a specific pest on a specific crop. This economic benefit or loss is measured in dollars per acre for the highest and lowest yield increase developed from experimental tests conducted by the pesticide producers and the state agricultural experimental stations. The high and low yield increases are multiplied by the price of the crop and reduced by the cost of the methyl parathion applied to generate the range of economic benefits in dollars per acre.

Most of the studies concerning the efficacy and yield charges due to the use of methyl parathion have been conducted on cotton crops for the control of the bollworm, boll weevil and tobacco budworm. The Texas Agricultural Experiment Station has conducted yearly studies which provide a history of the changes in efficacy. Sufficient data were also available from experiment stations in Louisiana, Mississippi, Georgia, and South Carolina.

Other pest crop combinations for which we found literature that compared yields with use rates included: the sorghum midge and greenbug on sorghum, the greenbug on wheat and the sunflower moth on sunflowers.

These results are summarized in the following paragraphs.

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[1] Headley, J. C., and J. N. Lewis, The Pesticide Problem: An Economic Approach to Public Policy, Resources for the Future, Inc., pp. 39-40 (1967).

Cotton

The use of methyl parathion on cotton in 1972 is estimated at 33,500,000 lb of active ingredient, i.e., 84.3% of the total domestic consumption. It is primarily used to control the cotton boll weevil, bollworm and tobacco budworm, but is also recommended for control of thrips, cotton leafworms, grasshoppers, fall armyworms, spider mites, fleahoppers, lygus bugs, aphids, garden webworms, false chinch bugs, cabbage loopers and cutworms.

Methyl parathion can be applied by itself or in combinations with other insecticides. Prior to the restriction of DDT a typical application consisted of 0.5 gal/acre of a mixture of 4 lb toxaphene, 2 lb DDT and 0.5 lb of methyl parathion to control bollworms. The number of applications would vary depending upon the degree of infestation. A high-use farmer might make 14 to 15 total applications, with one or two of these applications consisting solely of methyl parathion to suppress the late hatch of bollworms. Many states are now recommending a formulation consisting of 6 lb of toxaphene and 3 lb of methyl parathion per gallon at a rate of 1 to 2 qt/acre.

Efficacy Against Pest Infestation - The use of methyl parathion expanded significantly as resistance of the tobacco budworm to DDT increased. Adkisson et al. (1965)1/ found a high level of DDT resistance in the budworm and bollworm. Tests showed that methyl parathion killed 85% of the bollworm larvae when applied at 0.25 lb/acre whereas 1.0 lb/acre of DDT killed only 51%.

Wolfenbarger et al. (1971)2/ found that methyl parathion killed 85% of the bollworms and tobacco budworms. Yields in a test at Brownsville, Texas, in 1967 increased 689 lb of seed cotton over the check. Good control of the bollworm, tobacco budworm, and pink bollworm was achieved.

1/ Adkisson, Perry L., and Stanley Nemec, "Efficiency of Certain Insecticides for Killing Bollworms and Tobacco Budworms," Progress Report PR-2357, Texas Agr. Exp. Sta. (1965).

2/ Wolfenbarger, D. A., and Rex McGarr, "Low Volume and Ultra-Low Volume Sprays of Malathion and Methyl Parathion for Control of Three Lepidopterous Cotton Pests," Production Research Report No. 126, U.S. Department of Agriculture and Texas Agr. Exp. Sta. (1971).

Nemec et al. (1968)[1] evaluated ULV and CLV methyl parathion sprays at College Station, Texas in 1966 and achieved 100% kill of the bollworm and budworm 48 hr after application of 1.0 lb/acre. They concluded that ULV sprays should provide more effective and economical control.

Hopkins et al. (1970)[2] evaluated methyl parathion and other insecticides in 1968 and 1969 at Florence, South Carolina, and found that methyl parathion gave good control of the bollworm and boll weevil. Yields increased 1,629 lb/acre in 1968 and 867 lb/acre in 1969 compared to the untreated checks. The yields from the untreated checks were 255 and 10 lb/acre, respectively.

Adkisson et al. (1967)[3] compared various insecticides and found that methyl parathion at 1.0 lb/acre killed 100% of the bollworm larvae after 48 hr and 89% kill was achieved when methyl parathion was applied at 0.5 lb/acre. They also found that 0.75 lb/acre methyl parathion provided 97% kill of tobacco budworm larvae after 48 hr and 100% kill of the adult boll weevil under the same conditions when 0.25 lb/acre were applied. These tests were conducted at College Station, Texas, in 1966.

McGarr et al. (1969)[4] evaluated insecticides at Brownsville, Texas, in 1968 and reported that although methyl parathion was effective against the budworm and bollworm it did not give adequate control. Yield increases from three tests varied from 6 to 219 lb/acre. When methyl parathion was applied at 2.0 lb/acre, better control was achieved and yields increased 845 lb/acre.

In 1968, Nemec et al. (1968)[5] noted that the tobacco budworm population in the Lower Rio Grande Valley, and perhaps near College Station had developed a low-level resistance to methyl parathion: large doses of the insecticide were needed to kill the budworms in laboratory tests. The LD_{50} values had also indicated a 2.0- to 2.5-fold increase over the previous year. These tests showed a 97% kill in 48 hr when applied at 2.0 lb/acre on College Station larvae. This dropped to a 41% kill rate when 0.5 lb/acre was applied. There were no indications of resistance in the bollworm or voll weevil.

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[1] Nemec, S. J., P. L. Adkisson, and H. W. Dorough, "Laboratory Tests of Ultra-Low Volume and Conventional Low Volume Sprays for Controlling the Bollworm and Tobacco Budworm," J. Econ. Entomol., 61:209-213 (1968).

[2] Hopkins, A. R., H. M. Taft, W. James, and C. E. Jernigan, "Evaluation of Substitutes for DDT in Field Experiments fof Control of the Bollworm and the Boll Weevil in Cotton, 1967-1969," J. Econ. Entomol., 63:848-850 (1970).

[3] Adkisson, Perry L., and S. J. Nemec, "Insecticides for Controlling the Bollworm, Tobacco Budworm, and Boll Weevil," MP-837, Texas Agr. Exp. Sta. (1967).

[4] McGarr, R. L., and D. A. Wolfenbarger, "Field Evaluations of Insecticides for Control of Cotton Insects, Brownsville, 1968," Progress Report PR-2670, Texas Agr. Exp. Sta. (1969).

[5] Nemec, S. J., P. L. Adkisson, and H. W. Dorough, "Laboratory Tests of Ultra-Low Volume and Conventional Low Volume Sprays for Controlling the Bollworm and Tobacco Budworm," J. Econ. Entomol., 61:209-213 (1968).

Nemec conducted similar tests in 1969 (Nemec, 1970[1]) and found that the LD_{50} value for methyl parathion increased 1.5-fold over the 1968 value in budworms from the Brazos River Valley and twofold over the 1968 value in the Welasco area. Methyl parathion at 2.0 lb/acre resulted in a 90% kill in 48 hr at College Station in 1969. At 0.5 lb/acre it gave a 44% kill. In Welasco the results at the above rates were 79% and 23%, respectively.

Nemec et al. (1973)[2] summarized the yearly tests comparing the effect of methyl parathion on the budworm and bollworm. He reported that prior to 1968 when resistance was detected in the budworm the cost of control was $28/acre. By 1972 the cost for control of the bollworm complex averaged $60/acre due to higher rates and more frequent applications of insecticides, greater populations of the budworm and higher costs of certain insecticides.

The results of tests showed that the LD_{50} values for methyl parathion on the budworm increased 50-fold between 1964 and 1972 at College Station, Texas. A fivefold increase from 1968 to 1972 was reported in the Rio Grande Valley, Texas.

Some resistance of the bollworm to methyl parathion was also indicated. The LD_{50} values at College Station were at the same level from 1967 to 1971, but doubled in 1972. Bollworms in the Pecos area were shown to be more tolerant to methyl parathion than those from College Station.

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[1] Nemec, S. J., "Topical Application and Caged Plant Evaluations of Insecticide Toxicities to Bollworms, Tobacco Budworms and Boll Weevils," Progress Report PR-2845, Texas Agr. Exp. Sta. (1970).

[2] Nemec, S. J., and P. L. Adkisson, "Organophosphate Insecticide Resistance Levels in Tobacco Budworm and Bollworm Populations in Texas, Investigations of Chemicals for Control of Cotton Insects in Texas," Technical Report No. 73-20, pp. 18-25, Texas Agr. Exp. Sta. (1973).

Wolfenbarger et al. (1973)[1] evaluated budworm resistance to methyl parathion in Texas, Mexico, Central America, Florida, and Mississippi, and found the highest levels of resistance in the Mante Tampico area of Mexico. They concluded that these insects in this area and Brownsville, Texas were resistant to methyl parathion while those in Mississippi, Southern and Western Mexico were susceptible. The bollworms from Central America and Southern Mexico were resistant to methyl parathion whereas the United States resident bollworms were susceptible.

Apparently, the resistance of the budworm to methyl parathion is limited to the Texas area. Canerday (1974)[2] showed that there were no substantial and consistent differences in the response of bollworms and budworms to methyl parathion in tests conducted in Georgia between 1970 and 1972.

Cost Effectiveness of Pest Control - Numerous studies have been conducted comparing increased yields of methyl parathion treated cotton. Most of these studies were made available from the Texas Agricultural Experiment Station and were supplemented by tests conducted in Mississippi, Louisiana, and South Carolina. The tests covered the period from 1956 to 1972. The 1972 price received by farmers for cotton was 24.0¢/lb for lint. Additional income from cottonseed of 4.2¢/lb and government price supports of 12.5¢/lb brought the total income to 40.7¢/lb of cotton (Agricultural Statistics, 1973[3]). Methyl parathion costs averaged $1/lb in 1972 (Chambers and Miller, 1974[4]).

The range of yield changes from all of the data reviewed varied from a loss of 52 lb/acre to an increase of 1,629 lb when compared to untreated test plots. The economic benefit after subtracting the cost of the methyl parathion ranged from a loss of $30.16/acre to a gain of $653.25/acre.

The results of the yield tests are tabulated in Table 25.

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[1] Wolfenbarger, D. A., M. J. Lukefahr, and H. M. Graham, "LD_{50} Values of Methyl Parathion and Endrin to Tobacco Budworm and Bollworms Collected in the Americas and Hypothesis on the Spread of Resistance in These Lepidopterans to These Insecticides," J. Econ. Entomol., 66:211-216 (1973).

[2] Canerday, T. D., "Response of Bollworm and Tobacco Budworm in Georgia to Methyl Parathion," J. Econ. Entomol., 67:299 (1974).

[3] Agricultural Statistics, 1973, U.S. Department of Agriculture (1973).

[4] Chambers, William, and Daniel Miller, Farmland Industries, Kansas City, Missouri, personal communication with Mr. David F. Hahlen (1974).

Table 25. RESULTS OF METHYL PARATHION APPLIED TO COTTON PESTS

Date	Application Rate (lb AI/acre)	Application No.	Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Application cost (AI $1/lb + 50¢/application)	Economic benefit* ($)	Source
1967	1.25	8	436	177.45	14.00	163.45	a/
1956	0.3	9	1,530	622.71	7.20	615.51	b/
1956	0.25	9	476	193.73	6.75	186.98	
1959	0.25	13	68	27.67	9.75	17.92	
1960	0.25	14	265	107.86	10.50	97.36	
1961	0.25	13	290	118.03	9.75	108.28	
1967	0.25	11	487	198.21	8.25	189.96	
1967	0.75	11	194	78.96	13.75	65.21	
1968	1.0	6	119	48.43	9.00	39.43	
1969	1.0	10	775	315.42	15.00	300.42	
1971	0.25	7	122	49.65	5.25	44.40	
1971	0.125	7	158	64.31	4.38	59.93	
1971	0.25	7	97	39.48	5.25	34.23	
1971	1.0	7	255	103.79	10.50	93.29	
1972	1.0	10	197	80.18	15.00	65.18	
1973	1.0	3	34	13.84	4.50	9.34	
1972	1.0	12	366	148.96	18.00	130.96	
1971	1.0	7	337	137.16	10.50	126.66	
1971	1.0	8	499	203.09	12.00	191.09	
1963	1.0	12	350	142.45	18.00	124.45	c/
1966	1.0	9	165	67.15	13.50	53.65	
1969	1.0	8	547	222.63	12.00	210.63	
1971	1.0	7	376	153.03	10.50	142.53	
1971	1.0	7	460	187.22	10.50	176.72	
1966	1.0	9	177	72.04	13.50	68.54	
1966	1.0	9	75	30.53	13.50	17.03	
1969	1.0	7	773	314.61	10.50	307.11	
1973	1.0	5	220	89.54	7.50	82.04	
1967	0.75	12	201	81.81	15.00	66.81	d/
1968	0.75	4	157	63.90	5.00	58.90	
1969	0.75	9	801	326.01	11.25	319.76	
1968	0.75	13	1,629	663.00	16.25	647.25	e/
1969	1.0	16	867	352.87	24.00	328.87	
1967	1.0	17	689	280.42	25.50	354.92	f/
	1.0	17	576	234.43	25.50	208.93	
1968	1.0	6	219	89.13	9.00	80.13	g/
	1.0	11	175	71.23	16.50	54.73	
	0.75	12	6	2.44	15.00	(12.56)	
	2.0	17	845	343.91	42.50	301.41	
1968	2.0	12	800	325.60	30.00	295.60	h/
	1.25	12	636	258.85	21.00	237.85	
1968	1.25	8	419	170.53	14.00	156.53	a/
	1.0	6	629	256.00	9.00	247.00	
	0.75	6	411	167.28	7.50	159.78	

Table 25. (Continued)

Date	Application		Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Application cost (AI $1/lb + 50¢/ application)	Economic benefit* ($)	Source
	Rate (lb AI/acre)	No.					
1969	1.5	6	65	26.46	12.00	14.46	g/
	1.5	6	105	42.74	12.00	30.74	
	1.6	8	65	26.48	16.80	9.68	
	2.0	13	601	244.61	31.50	213.11	
1969	1.5	12	236	96.05	24.00	72.05	i/
1969	1.17	6	115	46.81	10.02	36.79	j/
1970	1.5	4	290	118.00	8.00	110.00	k/
1971	1.5	6	98	39.89	12.00	27.89	l/
	1.5	6	(52)	(21.16)	12.00	33.16	
1971	1.5	8	439	178.67	16.00	162.67	m/
	1.5	8	596	242.57	16.00	226.57	
	0.8	8	449	182.74	10.40	172.34	
	1.5	8	711	289.38	16.00	273.38	
	1.5	8	614	249.90	16.00	233.90	
	0.8	8	384	156.29	10.40	155.89	
1972	1.5	10	414	168.50	20.00	148.50	n/
1972	1.5	8	364	148.15	16.00	132.15	o/

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* Data in parentheses indicate decreases yield, income, and economic benefit.

a/ Cowan, C. B., Jr., and J. W. Davis, "Field Tests With Conventional Low Volume or Ultra-Low Volume Sprays for Control of the Boll Weevil, Bollworm, and Tobacco Budworm on Cotton in 1967," J. Econ. Entomol., 61:1115-1116 (1968).

b/ Bost, W. M., Director, Cooperative Extension Service, Mississippi State University, State College, Mississippi, Summary of Test Results at Stoneville and Verona, Mississippi, and Costs of Pesticides, personal letter to Mr. David F. Hahlen.

c/ Cox, John A., Director, Louisiana Cooperative Extension Service, Baton Rouge, Louisiana, Summary of Test Results in Louisiana, personal letter to Mr. David F. Hahlen (1974).

d/ Legett, J. E., T. C. Cleveland, and W. P. Scott, "Comparison of Several Insecticide Combinations for Control of Heliothis spp.," J. Econ. Entomol., 65:1182 (1972).

e/ Hopkins, A. R., H. M. Taft, W. James, and C. E. Jernigan, "Evaluation of Substitutes for DDT in Field Experiments for Control of the Bollworm and the Boll Weevil in Cotton, 1967-1969," J. Econ. Entomol., 63:848-850 (1970).

f/ Wolfenbarger and McGarr, op. cit. (1971).

g/ McGarr and Wolfenbarger, op. cit. (1969).

Table 25. (Continued)

h/ Hanna, R. L., "Field Performance of Chemicals for Control of Tobacco Budworms, Bollworms, and Carmine Spider Mites on Cotton, College Station, 1968," Progress Report PR-2671, Texas Agr. Exp. Sta. (1969).

i/ Hanna, R. L., "Field Tests of Chemicals for Control of Tobacco Budworms, Bollworms, and Carmine Spider Mites on Cotton, College Station," Progress Report PR-2842, Texas Agr. Exp. Sta. (1970).

j/ Cowan, C. B., Jr., and J. W. Davis, "Field Evaluation of Insecticides for Control of the Boll Weevil, Bollworm and Tobacco Budworm on Cotton, Waco Area, Central Texas, 1968," Progress Report PR-2672, Texas Agr. Exp. Sta. (1969).

k/ Hanna, R. L., "Field Tests of Chemicals for Control of Tobacco Budworms and Bollworms on Cotton, College Station," Technical Report 19, pp. 19-22, Texas Agr. Exp. Sta. (1971).

l/ McGarr, R. L., "Field Tests With the Delta-Endotoxin of *Bacillus thuringiensis* HD-1 and Chemical Insecticides for Control of the Tobacco Budworm and Bollworm and the Cotton Leafperforator, 1970 and 1971, Investigations of Chemicals for Control of Cotton Insects in Texas 1970-1971," Progress Report PR-3082, pp. 1-4, Texas Agr. Exp. Sta. (1972).

m/ Hanna, R. L., "Field Tests of Chemicals for Control of Tobacco Budworms and Bollworms on Cotton, College Station, Investigations of Chemicals for Control of Cotton Insects in Texas, 1970-1971," Progress Report PR-3084, pp. 22-36, Texas Agr. Exp. Sta. (1972).

n/ Cowan, C. B., Jr., and J. W. Davis, "Chemicals Evaluated in Field Tests Against Cotton Insects, Investigations of Chemicals for Control of Cotton Insects in Texas," Technical Report No. 73-20, pp. 9-12, Texas Agr. Exp. Sta. (1973).

o/ McGarr, R. L., "Field Tests With *Bacillus thuringiensis* HD-1 and Chemical Insecticides for Control of the Tobacco Budworm and the Bollworm at Brownsville, Texas, 1972, Investigations of Chemicals for Control of Cotton Insects in Texas," Technical Report No. 73-20, pp. 13-17, Texas Agr. Exp. Sta. (1973).

Sorghum

Methyl parathion is registered for control of aphids, greenbugs, spider mites and the sorghum midge on sorghum. Of these the sorghum midge and the greenbug are the two most important insects affecting yield.

Efficacy Against Sorghum Midge Infestation - In the early 1960's the sorghum midge temporarily caused serious crop losses. However, early uniform planting has restricted damage from this insect to isolated late-planted fields (Cate et al., 1973[1]). Huddleston et al. (1972)[2] reported on tests of insecticides for control of the midge and concluded that methyl parathion was effective at 0.5 lb/acre but its phytotoxic properties limited its use. However, the results of two evaluations were mixed. Huddleston also reported that yields in a test at Lubbock, Texas, in 1963, increased from 544 to 3,133 lb/acre over untreated checks when increasing amounts of methyl parathion were applied. Conversely, a similar test conducted at Plainview, Texas, in 1964, showed that yields compared to an untreated check ranged from a 132 lb/acre increase to a 330 lb/acre loss as increasing amounts and applications of methyl parathion were applied.

Cost Effectiveness of Sorghum Midge Control - The above cited paper by Huddleston et al., was the only one which compared yields of methyl parathion treated sorghym plots against an untreated check. The results of two separate experiments showed yield changes ranging from a loss of 330 lb/acre to an increase of 3,133 lb/acre. The price of sorghum averaged $2.25/cwt in 1972 (Agricultural Statistics, 1973) and the cost of methyl parathion was $1/lb (Chambers and Miller, 1974). At these prices and costs, the economic benefits would range from a loss of $8.43/acre to a gain of $68.49/acre.

These tests are summarized in Table 26.

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[1] Cate, J. R., Jr., D. G. Bottrell, and G. L. Teetes, "Management of the Greenbug on Grain Sorghum. I. Testing Foliar Treatments of Insecticides Against Greenbugs and Corn Leaf Aphids," J. Econ. Entomol., 66:945-951 (1973).

[2] Huddleston, E. W., D. Ashdown, B. Maunder, C. R. Ward, G. Wilde, and C. E. Forehand, "Biology and Control of the Sorghum Midge. I. Chemical and Cultural Control Studies in West Texas," J. Econ. Entomol., 65:851-855 (1972).

Table 26. RESULTS OF METHYL PARATHION APPLIED TO THE SORGHUM MIDGE

	Application						
Date	Rate (lb AI/acre)	No.	Yield increase* (lb/acre)	Additional income* ($/acre at $2.25/cwt)	Application cost (AI $1/lb + 50¢/ application)	Economic benefit* ($)	Source
1963	0.5	1	544	12.24	1.50	11.74	a/
	1.0	1	1,123	25.27	1.50	24.27	
	0.5	2	2,372	53.37	2.00	52.37	
	1.0	2	3,133	70.49	3.00	68.49	
1964	0.5	1	132	2.97	1.00	2.47	
	1.0	1	242	5.45	1.50	4.45	
	0.5	2	(330)	(7.43)	2.00	(8.43)	
	0.5	2	(132)	(2.97)	2.00	(4.97)	

* Data in parentheses indicate decreases in yield, income, and economic benefit.

a/ Huddleston et al., op. cit. (1972).

Greenbug

Efficacy Against Greenbug Infestation - Although there are numerous insects affecting sorghum, perhaps the greenbug causes the greatest damage. Prior to 1968, the greenbug had been found mostly in small grains such as wheat, barley, and oats. However, in 1968 a new biotype emerged and began infesting sorghum. Ward et al. (1970)1/ noted that in 1968, 7.3 million acres became infested resulting in a production loss estimated at $20 million. Cate et al. (1973) reported that the Grain Sorghum Producers Board estimated that $14 million was spent for control of grain sorghum pests in 1970 compared with only $100,000 spent prior to 1968.

Methyl parathion gives good control of greenbugs. Daniels (1971)2/ treated sorghum with 0.5 lb of methyl parathion per acre at Bushland, Texas, in 1968. Greenbug control was 94% at the end of a week and within 3 weeks live greenbugs disappeared. During this time, plants without treatment died 14 days after greenbug populations reached 13,500/plant. Yields increased 5%. In a similar test in 1969, greenbug reduction averaged 90% over a 29-day period.

1/ Ward, C. R., E. W. Huddleston, D. Ashdown, J. C. Owens, and K. L. Polk, "Greenbug Control on Grain Sorghum and the Effects of Tested Insecticides on Other Insects," J. Econ. Entomol., 63:1929-1934 (1970).

2/ Daniels, N. E., "Insecticidal Greenbug Control in Grain Sorghum, Research on Grain Sorghum Insects and Spider Mites in Texas," Progress Report PR-2868, pp. 16-20, Texas Agr. Exp. Sta. (1971).

Cate et al. (1973) also reported 95% control after 21 days in tests conducted in Lubbock County, Texas, in 1970. Teetes et al. (1973)[1] reported 95% control of greenbugs 14 days after application of 0.25 lb/acre of methyl parathion in tests at Lubbock, Texas, in 1972. When applied at 0.5 lb/acre, 96% control was achieved in 14 days.

Although methyl parathion controls greenbugs, it appears to be phytotoxic to sorghum and can, under some conditions, result in yield reductions. Meisch et al. (1970)[2] evaluated insecticides for phytotoxicity and found methyl parathion caused severe leaf damage and reduced yields on five of six varieties of sorghum when applied at 1.0 lb/acre and reduced yields on four of the six when applied at 0.5 lb/acre. Cate et al. (1973) found that EC methyl parathion burned the top leaves but the encapsulated formulation did not cause phytotoxicity.

Cost Effectiveness of Greenbug Control - The results of several tests in Texas show that yield changes varied from a loss of 563 lb/acre to a gain of 605 lb/acre when methyl parathion was used to control the greenbug.

The price of sorghum averaged $2.25/cwt in 1972 (Agricultural Statistics, 1973) and the cost of methyl parathion was $1/lb (Chambers and Miller, 1974). At these prices and costs, the economic benefits would range from a loss of $13.67/acre to a gain of $13.11/acre for the use of methyl parathion to control the greenbug.

These tests are summarized in Table 27.

Wheat

The greenbug has been regarded as the most destructive of the aphids infecting small grains since its introduction into North America in the Nineteenth Century.

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[1] Teetes, G. L., G. W. Brothers, and C. R. Ward, "Insecticide Screening for Greenbug Control and Effect on Certain Beneficial Insects," Progress Report PR-3166, Texas Agr. Exp. Sta. (1973).

[2] Meisch, N. V., George L. Teetes, N. M. Randolph, and A. J. Bockholt, "Phytotoxic Effects of Insecticides on Six Varieties of Grain Sorghum," J. Econ. Entomol., 63:1516-1517 (1970).

Table 27. RESULTS OF METHYL PARATHION APPLIED TO THE SORGHUM GREENBUG

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income* at \$2.25/cwt (\$/acre)	Application cost (AI \$1/lb + 50¢/ application)	Economic benefit* (\$)	Source
1968	0.5	(413)	(9.29)	1.00	(10.29)	a/
1970	0.5	317	7.13	1.00	6.13	b/
	0.25	283	6.37	0.75	5.62	b/
1969	1.0	(563)	(12.67)	1.50	(14.17)	c/
	0.5	147	3.31	1.00	2.31	
	1.0	(147)	(3.31)	1.50	(4.81)	
	0.5	(292)	(6.57)	1.00	(7.57)	
	1.0	(560)	(12.60)	1.50	(14.10)	
	0.5	(490)	(11.03)	1.00	(12.03)	
	1.0	(488)	(10.98)	1.50	(12.48)	
	0.5	(478)	(10.76)	2.00	(11.86)	
	1.0	(407)	(9.16)	1.50	(10.56)	
	0.5	(115)	(2.59)	1.00	(3.59)	
	1.0	450	10.13	1.50	8.63	
	0.5	605	13.61	1.00	12.61	
1972	0.25	140	3.15	0.75	2.40	d/
	0.5	(166)	(3.74)	1.00	(4.74)	
1968	0.5	327	7.36	1.00	6.36	e/

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* Data in parentheses indicate decreases, yield, income, and economic benefit.

a/ Ward et al., op. cit. (1970).

b/ Cate et al., op. cit. (1973).

c/ Meisch et al., op. cit. (1970).

d/ Teetes et al., op. cit. (1973).

e/ Daniels, N. E., op. cit. (1971).

Efficacy Against Greenbug Infestation - As a result of a heavy infestation of greenbugs in Texas in 1961, Daniels (1962)[1] evaluated several insecticides for their control on wheat crops. These tests at Bushland, Texas, in 1961 resulted in satisfactory control with methyl parathion. In two experiments, an average of 94% reduction was achieved in both tests. Yields increased 7 and 11.73 bushels per acre, respectively.

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[1] Daniels, N. E., "Insecticidal Control of the Greenbug," Progress Report PR-2247, Texas Agr. Exp. Sta. (1962).

Ward et al. (1972)[1] screened various insecticides at Clovis, New Mexico, in 1969 and reported a 99% reduction in greenbugs after 14 days with methyl parathion. Yields increased by 400 lb/acre or 6.67 bushels.

Cost Effectiveness of Greenbug Control - Yield increases based upon the three tests reported above varied from 6.67 to 11.73 bushels per acre. At a price of $1.67/bushel for wheat in 1972 (Agricultural Statistics, 1973) and a cost of $1/lb for methyl parathion (Chambers and Miller, 1974), the economic benefit would range from $10.64 to $19.09/acre from control of the greenbug on wheat.

These are summarized in Table 28.

Table 28. RESULTS OF METHYL PARATHION APPLIED TO THE WHEAT GREENBUG

Date	Application (lb AI/acre)	Yield increase (bu/acre)	Additional increase at $1.67/bu ($/acre)	Application cost (AI $1/lb + 50¢/ application)	Economic benefits (loss $)	Source
1961	0.5	7.00	11.69	1.00	10.69	a/
	0.5	11.73	19.59	1.00	18.59	
1968	0.5	6.67	11.14	1.00	10.14	b/

a/ Daniels, N. E., op. cit. (1962).
b/ Ward et al., op. cit. (1972).

Sunflowers

Methyl parathion is recommended for control of the sunflower moth which is a signficant pest that attacks the seed of the commercial sunflower.

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[1] Ward, C. R., J. Ownes, D. Ashdown, E. Huddleston, and W. Turner, "Greenbug Control on Wheat in 1967-1969," J. Econ. Entomol., 65:764-767 (1972).

Efficacy Against Pest Infestation - Teetes et al. (1968)[1] tested several insecticides at College Station, Texas, in 1967. Methyl parathion at 1.0 lb/acre effectively reduced the larvae and increased yields by 65% over an untreated check. In a similar test at McGregor, Texas, three applications resulted in a greater reduction of insects. A second test at McGregor showed greater yields with multiple applications at 5-day intervals than 15-day intervals.

Teetes et al. (1969)[2] repeated tests at McGregor, Texas, and achieved a 54% reduction in the sunflower moth and a 256% increase in yield with two applications of 0.5 lb/acre methyl parathion. With three applications at this rate, a 91% reduction in moths was achieved with a corresponding 412% increase in yield. Similar results were achieved in experiments at McGregor in 1969 (Teetes et al., 1971[3]).

Carlson (1971)[4] tested several insecticides at Davis, California in 1968 and in two experiments found that methyl parathion gave 79% and 97% reduction of seed damage with corresponding increases of 611 and 227 lb of seed per acre.

Cost Effectiveness of Pest Control - The results of the various tests comparing yield increases with methyl parathion application rates show increases varying from a loss of 21 lb/acre to a gain of 792 lb/acre. The prices for sunflower seeds are $7.50/cwt (Kantack, 1974[4]) and methyl parathion costs are $1/lb (Chambers and Miller, 1974). At these prices and costs, the economic benefits vary from a loss of $2.58/acre to a gain of $57.90/acre from the use of methyl parathion to control the sunflower moth.

The test results are summarized in Table 29.

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[1] Teetes, G. L., and N. M. Randolph, "Chemical Control of the Sunflower Moth on Sunflowers," J. Econ. Entomol., 61:1344-1347 (1968).

[2] Teetes, G. L., and N. M. Randolph, "Effects of Pesticides and Dates of Planting Sunflowers on the Sunflower Moth," J. Econ. Entomol., 64:124-126 (1971).

[3] Carlson, E. C., "New Insecticides to Control Sunflower Moth," J. Econ. Entomol., 64:208-209 (1971).

[4] Kantack, B. H., Extension Entomologist Cooperative Extension Service, Brookings, South Dakota, Summary of Tests, personal correspondence to Mr. David F. Hahlen (1974).

Table 29. RESULTS OF METHYL PARATHION APPLIED TO THE SUNFLOWER MOTH

	Application						
Date	Rate (lb AI/acre)	No.	Yield increase* (lb/acre)	Additional increase* ($/acre at $7.50/cwt)	Application cost (AI $1/lb + 50¢/ application)	Economic benefit* ($)	Source
1967	1.0	1	382	28.65	1.50	27.15	a/
	1.0	1	50	3.75	1.50	2.25	
	1.0	2	150	11.25	3.00	8.25	
	1.0	3	200	15.00	4.50	10.50	
	1.0	1	(21)	(1.58)	1.50	(3.08)	
	1.0	2	158	11.85	3.00	8.85	
	1.0	3	142	10.65	4.50	1.15	
	1.0	3	300	22.50	4.50	18.00	
	1.0	3	148	11.10	4.50	6.60	
	1.0	3	80	6.00	4.50	1.50	
	1.0	1	(17)	(1.28)	1.50	(2.78)	
	1.0	1	(12)	(0.90)	1.50	(2.40)	
	1.0	1	75	5.63	1.50	4.13	
	1.0	1	146	10.95	1.50	9.45	
	0.5	2	490	36.75	2.00	34.75	b/
	0.5	3	792	59.40	3.00	56.40	
	0.5	2	686	51.45	2.00	49.45	
	1.0	2	316	23.70	3.00	22.70	c/
	1.0	3	507	38.03	4.50	33.53	
	1.0	1	566	42.45	1.50	40.95	
	1.5	1	611	45.83	2.00	43.83	d/
	1.5	1	227	17.03	2.00	15.03	

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* Data in parentheses indicate decreases in yield, income, and economic benefit.

a/ Teetes et al., op. cit. (1968).

b/ Teetes, G. L., and N. M. Randolph, "Chemical Control and Cultural Control of the Sunflower Moth in Texas," J. Econ. Entomol., 62:1444-1446 (1969).

c/ Teetes, G. L. and N. M. Randolph, "Effects of Pesticides and Dates of Planting Sunflowers on the Sunflower Moth," J. Econ. Entomol., 64:124-126 (1971).

d/ Carlson, E. C., "New Insecticides to Control Sunflower Moth," J. Econ. Entomol., 64:208-229 (1971).

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